DOT/FAA/CT-83/34
SEVILLE TR-83-17

AD-A133 400

Private Pilot Flight Skill Retention 8, 16, and 24 Months Following Certification

Jerry M. Childs
William D. Spears
Wallace W. Prophet

Seville Research Corporation
400 Plaza Building
Pensacola, Florida 32505

July 1983

This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

Prepared under Subcontract to:

Embry-Riddle Aeronautical University
Regional Airport
Daytona Beach, Florida 32014

for

US Department of Transportation
Federal Aviation Administration
Technical Center
Atlantic City Airport, N.J. 08405

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-83/34	AD-A133400	

4. Title and Subtitle	5. Report Date
Private Pilot Flight Skill Retention 8, 16, and 24 Months Following Certification	July 1983
	6. Performing Organization Code
7. Author(s) J. M. Childs, W. D. Spears, W. W. Prophet	8. Performing Organization Report No. Seville TR 83-17
9. Performing Organization Name and Address Seville Research Corporation 400 Plaza Building Pensacola, FL 32505	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DOT-FA79NA-6040
12. Sponsoring Agency Name and Address Federal Aviation Administration Technical Center Atlantic City Airport, NJ 08405	13. Type of Report and Period Covered Final Report January 1981-June 1983
	14. Sponsoring Agency Code

15. Supplementary Notes

*Under Subcontract to: Embry-Riddle Aeronautical University
Regional Airport
Daytona Beach, Florida 32014

16. Abstract

This report describes the results of a 2-year longitudinal research program to assess objectively the skill retention levels of relatively low time private pilots. Objectives of this effort were to identify (1) retention patterns for skills needed to perform a representative range of private pilot flight tasks; (2) factors influencing the retention of these skills and the nature and degree of such influences; and (3) continuation training methods to maintain or upgrade the skills. A secondary objective was to assess pilots' ability to predict and evaluate their own proficiency levels.

Results are summarized for flight skill retention checks conducted 8, 16, and 24 months following private pilot certification. Proficiency loss was documented for all subjects and for each flight task studied, and the losses were statistically significant in nearly all cases. Tasks that were relatively high, low, and more rapid in skill loss were identified, and the effects of interpolated training on skill loss patterns were assessed. Pilots' ability to predict and evaluate their own skill retention levels for specific flight tasks was negligible. The present findings suggest that effective continuation training program and media are needed, especially to address cognitive types of flight skills. Several such potential media are described.

17. Key Words	18. Distribution Statement
Flight Skill Retention, Self-Assessment, Performance Assessment, Continuation Training, Retention, Proficiency Loss	This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	113	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

METRIC CONVERSION FACTORS

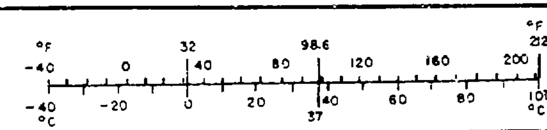
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

The retention of pilot flight skills is a critical factor in the overall safety and efficiency of general aviation operations. Data records of the National Transportation Safety Board indicate that the problem of flight skill retention among pilots of all experience levels is of great concern. This final report describes the results of a 2-year study to assess objectively the skill retention levels of relatively inexperienced private pilots 8, 16, and 24 months following their certification. Interim reports of this project summarized the assessments of 8-month and 16-month skill retention (references 1 and 2). This longitudinal investigation of general aviation pilot skill retention was sponsored by the Federal Aviation Administration (FAA) Technical Center. All pilot subjects who underwent the three skill retention checkrides for this study had received their private pilot certificates during the same period of time as part of an earlier FAA-sponsored project (reference 3). The objective in-flight data collection instrument used to gather performance data for the retention checks also was used earlier at the point of private pilot certification, thereby enabling meaningful data comparisons to be made. Flight skill retention checks conducted at 8-month intervals over the 2-year period helped to identify the specific nature and degree of the decrement function that occurs for infrequently practiced flight skills. Empirical data stemming from these checks should enable more valid judgments to be made concerning continuation training and evaluation requirements for general aviation pilots. In the present study, detailed background data were acquired pertaining to subjects' flying activities during the 2-year interval, and these data were related to measures of flight proficiency on each retention check.

This flight skill retention study was part of a more comprehensive program of research sponsored by the FAA Technical Center and designed to identify and address human factors problems in general aviation. Work on this research program was accomplished jointly by Embry-Riddle Aeronautical University (E-RAU) and the Seville Research Corporation under Contract No. DOT-FA79NA-6040. Seville's activities were conducted under subcontract to E-RAU. E-RAU provided the aircraft and checkpilot for this study. Seville was responsible for development of the measurement instruments, for analysis of the data, and for preparation of all reports.

E-RAU's efforts were under the management of Ms. Nena Backer, Coordinator, Aviation Education Design. Seville's program management was provided by Dr. Wallace W. Prophet. Dr. Jerry M. Childs was Project Director. Technical assistance for this report was provided by Drs. William D. Spears and Jack B. Shelnutt, and by Mr. Winon E. Corley of Seville. Mr. Anthony Frock, Mr. Paul Fink, and Mr. Gregory Lundberg of E-RAU performed many of the logistics related to preparation of test instruments, scheduling of test procedures, and assistance with familiarization flights. Mr. Guy Adsit served as E-RAU's checkpilot for all flight checks. He was responsible not only for all in-flight data collection, but also assisted in scheduling flight checks and administering the written tests. For Seville, Ms. Faye Sanders performed much of the data reduction and collation, and Ms. Carrie Morris served as Technical Editor. The Contracting Officer's Technical Representative for the FAA

Technical Center originally was Mr. Douglas P. Harvey. He was succeeded by Mr. Robert J. Ontiveros. They provided able overall cognizance of all work activities and reviewed drafts not only of this technical report, but others generated as part of the more comprehensive research program. Their efforts were, in all respects, supportive and helpful.

TABLE OF CONTENTS

(Continued)

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

(Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

EXECUTIVE SUMMARY

INTRODUCTION.

Flight skills will degrade over time if not exercised sufficiently for the pilot to be able to retain or improve them. Thus, pilots who do not fly for extended periods of time, or who fail to practice certain critical tasks when they do fly, may be expected to make errors. These errors can, in turn, contribute to a variety of safety problems from which accidents and incidents may be the end result.

The flying skill degradation problem can be addressed through effective continuation training programs. Such programs should be implemented on the basis of a clear perception of the flight skills that degrade over time and an understanding of the factors that affect this degradation. As part of a research program sponsored by the FAA, the present study was designed to identify and quantify factors that affect the retention of flying skills by general aviation pilots holding the private pilot certificate.

The pilot proficiency data analyzed in the present study were collected 8, 16, and 24 months after the subjects received their certificates. All data could be meaningfully compared since flight and written tests used to collect the skill retention data were identical to those used earlier in conjunction with private pilot certification.

Primary objectives of this study were (1) to identify retention patterns for the skills needed to perform the various contact and basic instrument flight maneuvers and procedures that private pilots are required to master for certification; (2) to identify factors that influence retention of these skills in general and determine the specific ways in which they interact to influence the retention of different skills; and (3) to develop implications for continuation training to promote skill retention among general aviation pilots. A secondary objective was to assess the ability of pilots to predict and evaluate their own proficiency.

This study was conducted at the FAA Technical Center, Atlantic City Airport, New Jersey. Subjects were personnel employed by the FAA. Of the initial 42 subjects, 21 were available for the final 24-month check. At the time of the final retention check, subjects had a mean of 162 total flight hours (standard deviation = 51 hours), and had flown a mean of 89 hours (standard deviation = 47 hours) since passing their private pilot flight test. Some of the subjects had received additional training interpolated between their private pilot flight test and the various retention checks, whereas other subjects received no such interpolated training.

All flight proficiency data were acquired via the use of an objective in-flight data collection instrument containing a standard sequence of flight tasks to be administered in the aircraft. Error percentages on tasks contained in the instrument served as the major dependent measure of skill

retention. However, four other types of data were collected on each subject. They were:

1. survey data concerning flying activities since certification.
2. scores on an adaptation of the FAA Private Pilot Written Test.
3. precheck (prediction) questionnaire data.
4. postcheck (evaluation) questionnaire data.

The experimental design for this study evolved into one in which comparisons were made of the skill retention levels of the subjects who underwent interpolated instrument training during the 24-month interval versus those subjects who did not.

A second performance comparison was derived from an examination of when interpolated training was received relative to the three retention checks. This comparison was between two training subgroups, one of which received most of its interpolated training before the 8-month check (Group A), and the other of which received most of its training after the 8-month check (Group B). Thus, the skill retention of these two subgroups and that of the no-training subgroup (Group C) was compared across flight checks.

RESULTS AND DISCUSSION.

Data were analyzed for all three retention checks relative to private pilot checkride performance. The majority of flying experience acquired by subjects during the 2-year interval occurred in conjunction with their participation in other FAA-sponsored training research projects. At the time of the 24-month check, a mean of more than 5 months had elapsed since subjects had flown, and most of the subjects' additional flying experience had accrued during the initial 12 months following private pilot certification.

General decrement in performance was apparent for all groups as represented by the decreases in percentage of correctly performed measures over time. With respect to combined groups, the decrement was curvilinear and approximated the classical "forgetting curve" described in the psychological literature. However, the pattern of the decrement was group-specific. Group A's decrement was delayed by the effects of its involvement in interpolated training occurring during the initial 8-month retention interval. Group B experienced substantial decrement initially but relatively less decrement during the second 8-month interval when the majority of its interpolated training was received. Group C, which received no interpolated training, experienced virtually all of its skill loss during the first 8 months. While Group A's decrement was relatively less than that of Groups B and C during the first 8 months, the decrement was statistically significant for all three groups, a finding of definite operational concern.

Skill decrement over the 24-month period was statistically significant for combined flight tasks, as well as for each task considered separately (except

one involving the use of a checklist). Flight tasks exhibiting the greatest and least decrement over the 2-year retention interval were identified.

Scores on written examinations significantly decreased over the initial 8-month period, but no relationship was found between these scores and in-flight error rates on the 8-month check.

Subjects demonstrated a moderate ability to predict and evaluate their own overall proficiency at the 8-month check. However, they were not accurate in the case of predictions/evaluations of specific flight tasks.

Results of the present study strongly indicate that private pilots who do not operate aircraft frequently need continuation training to maintain or upgrade flight skills. To attempt to identify the types of skills that degraded in the present study, an exploratory post hoc analysis was conducted of PPDR measures performed in error. This analysis revealed that cognitive/procedural components were frequently performed in error on the retention checks. For instance, all subjects failed to acknowledge at least one ATC instruction at some point during the 24-month check, and 70 percent of the subjects used improper entry procedures for one or more of the stall maneuvers. Both the general literature on skill retention and the results of the present study suggest that generation of methods to improve the retention of cognitive skills should be one of the primary objectives of continuation training. General aviation continuation training, as it presently exists, does not sufficiently address the cognitive/procedural types of skills that are rather rapidly lost during lapses in operations. Several continuation training approaches and media are described that are potentially useful in the aiding in the retention of cognitive skills. These include cognitive training, various training devices, and full mission simulation. Additionally, criteria for evaluating the usability of these training media are set forth.

CONCLUSIONS.

Based on the results presented and the discussion and implications thereof, a number of general conclusions can be drawn.

1. Recently certificated private pilots who do not fly regularly can be expected to undergo a relatively rapid and significant decrement in their flight skills. Further, such decrement will affect most flight tasks that are required of the private pilot.

2. The effect of interpolated flight training is to forestall (not prevent) skill decrement.

3. Instrument training, properly conducted, can exert positive effects on the retention of both contact and instrument flight tasks.

4. Greater and more pervasive performance decrements may be expected for flight tasks that require appreciable coordination between cognitive and control skills.

5. Written test (i.e., knowledge) scores decrease significantly during the 8-month period following certification; however, written test scores are not useful for predicting actual flight performance.

6. Private pilots who do not fly frequently need periodic diagnostic assistance to help them pinpoint specific flight tasks on which they need continuation training.

7. Continuation training methods should be skill-specific and emphasize the development and reinforcement of cognitive cues.

8. An urgent need exists for the development of more effective performance criteria and of continuation training methods designed to aid private pilots in meeting those criteria.

INTRODUCTION

OVERVIEW.

Flight skills, like any complex skills, will degrade over time if not exercised sufficiently for the pilot to be able to retain or improve them. Thus, when pilots do not fly for extended periods of time, their flying skills degrade, and they often will make errors when they resume flying. Even if pilots fly regularly, their skill in executing flight tasks that are not performed frequently, such as emergency procedures, still may degrade. Flight tasks that are performed improperly also will deteriorate, and if consistently practiced incorrectly, undesirable habit patterns will result.

The nature of the current civil aviation accident data system does not allow specific determination of the extent to which flying skill degradation may be related to general aviation accidents. However, circumstantial evidence, which will be reviewed later, indicates that skill degradation should be considered a serious problem. Further, certain trends in general aviation may exacerbate this problem in future years. Increasing aircraft operating costs and restrictions on general aviation flight operations, for example, have reduced the frequency with which many general aviation pilots are able to fly, particularly pilots who fly for personal business and recreational purposes. Such costs and restrictions also can serve to reduce the amount of continuation training that even pilots who fly regularly are able to obtain.

The flying skill degradation problem can only be addressed through effective continuation training programs. To be effective--and cost efficient--such training and associated pilot proficiency evaluations should focus on critical flight skills that are the most likely to degrade over time. Research on the retention of flight skills and other complex skills, however, has shown that a number of factors influence the way in which different skills are retained (references 4 through 7). Thus, knowledge of such factors and the way they influence the specific flying skills that are of interest is a necessary precondition for determining the flight tasks that should be evaluated in recurrent tests of pilot proficiency, and that should be included in continuation training.

Because of its continuing concern with improving the safety of all aspects of general aviation operations, the Federal Aviation Administration (FAA) has conducted a variety of research efforts aimed at improving airman safety. As one of such efforts, the present study was designed to aid in achieving a better understanding of factors influencing the retention of flying skills by general aviation pilots holding the private pilot certificate. The study was part of a 2 1/2 year investigation sponsored by the FAA Technical Center. During the initial phase of this investigation, the pilot subjects received the training necessary to qualify for the private pilot certificate (reference 3), and were tested just before their FAA flight check using an objective flight test, a written test, and other instruments prepared specifically for the present investigation. The pilot proficiency data analyzed in the present study were collected 8, 16, and 24 months after the subjects received their

certificates. The same flight and written tests were used to collect the skill retention data as were used in conjunction with the private pilot certification. Earlier reports in this project described retention levels at 8 months (reference 1) and at 16 months (reference 2) following certification. The present report describes the extent to which the subjects retained, over the 24-month period, the skills necessary to perform some 29 different flight tasks. Further, factors affecting the retention of different skills are identified and analyzed in terms of their influence on skill retention patterns.

BACKGROUND FOR THE PRESENT STUDY.

Impetus for assessing the retention of flying skills by private pilots during the early years following their certification is derived, in part, from the analysis of certain general aviation aircraft accident trends. These trends indicate that the accident rate for private pilots is quite high in the first 200 or so flight hours after they receive their private pilot certificate, particularly for certain types of accidents. For example, a National Transportation Safety Board (NTSB) study of fatal weather-related accidents occurring from 1964 to 1972 found that such accidents were approximately twice as prevalent for pilots with less than 300 hours of total flight time than for those with more than 3000 hours of experience (reference 8). A study of nonfatal weather-related accidents occurring from 1964 to 1974 found an even more pronounced trend; approximately 92 percent of the pilots involved in these accidents had less than 300 hours of total flight experience (reference 9).

Analyses of such accident data are confounded somewhat by the lack of exposure data--i.e., data describing the number of hours flown each year by pilots with different amounts of total flight experience--and other limitations in civil aviation accident data systems. Such limitations are discussed in Connor and Hamilton (reference 10), NTSB (reference 11), and Shelnutt, Childs, Prophet, and Spears (reference 12). These limitations preclude the specific determination of the severity of the accident problems of relatively new private pilots (e.g., those in the first 2-year period following their certification) in comparison with that of pilots with greater experience (e.g., more than 2 years since certification). However, the results of studies cited above and analyses of data summarized in NTSB annual reviews of general aviation aircraft accidents reveal that a continuing high percentage of the general aviation accidents involve private pilots with 100 to 300 total flight hours. In some years, for example, such accidents have accounted for over 30 percent of all general aviation accidents. Thus, the continuing high number of accidents in which these pilots are involved provides the impetus to investigate factors influencing their performance.

Obviously, the accidents in which these pilots have been involved can be attributed to many causes other than the degradation of flying skills. Unfortunately, data do not exist for any group of pilots that can be used to estimate the proportion of these accidents that can be attributed to skill degradation problems as opposed to other causes. The lack of such evidence is due to limitations in the way in which data concerning all pilot performance problems are collected, stored, accessed, and analyzed in the civil aviation accident data systems. Data are rarely collected, for example, concerning the

specific task(s) on which a general aviation pilot may have erred that caused an accident. Further, data are almost never collected concerning the frequency and recency with which the pilot performed the task in question during time periods recently preceding the accident.

Circumstantial evidence can be assembled, however, that reveals the potential seriousness of the skill degradation problem for all general aviation pilots, regardless of the amount of their total flight experience. For example, several analysts investigating the circumstances surrounding a number of different types of "pilot error" accidents have concluded that degradation of flying skills was a factor that contributed to the critical pilot performance problems that were observed (references 8, 9, 11, and 13 through 20). Some of these conclusions were based on observations that many of the pilots involved in the accidents had flown infrequently in the months preceding the mishaps. In other studies, the conclusions were based on determinations that many of the pilots involved in the mishaps probably had not recently performed or practiced the specific tasks on which they had erred.

An NTSB study of accidents following engine failures on light twin-engine aircraft furnishes an excellent example of the reasoning underlying the latter type of conclusion (reference 11). A major finding in the study was that many of these accidents indicated a lack of pilot proficiency in managing a light twin after loss of power in one engine. The data indicated that these accidents often involved highly experienced pilots (many had over 3000 total flight hours) as well as inexperienced pilots. Some of the accidents could be attributed in part to deficiencies in the pilots' original multiengine training. However, based on reviews of the accident cases in which the experienced pilots were involved and interviews with a number of general aviation pilots, the Safety Board concluded that inadequacies in (or lack of) recurrent training for skill maintenance might be more important as a contributing cause than the level of initial training.

The Safety Board's conclusion implies, as does common sense, that the pilot's ability to manage the aircraft following an engine failure degrades over time if the pilot does not practice the skills required for safe performance of this task. It is reasonable to presume that pilots infrequently exercise these skills because (1) the task in question occurs infrequently in routine flying due to the reliability of modern aircraft engines, (2) practice of these skills is inconvenient and expensive, and (3) current regulations governing pilot certification do not specifically require such practice. While the Safety Board's findings pertain specifically only to those accidents that were studied, it is conceivable that similar conditions may exist for other critical flight skills, such as those required for the performance of other emergency procedures.

In addition to indirect evidence from accident studies, evidence concerning the skill degradation problem also can be derived from research that has been conducted on the retention of complex skills (reference 7). Indeed, an extensive amount of research has been conducted on the retention and forgetting of flying skills in particular (references 4, 6, and 21).

While most of this research has been in military aviation, many of the findings are applicable to general aviation. The general pattern for the

degradation of most complex skills, when they are not practiced, is a relatively rapid loss of proficiency during the initial part of the retention period, followed by a relatively slower loss over time of skill components not originally affected. In aviation, this general pattern has been found consistently in research on pilots with various levels of experience and competence. Simply put, no pilot is immune to the loss of flying skills if those skills are not exercised. Further, much of the loss can be expected to occur in the initial part of the time period in which the skills are not exercised.

The specific relation between loss of flying skills and time, however, is determined by several factors. Such factors include, for example, the type of task that is being performed, the original level of the pilot's skill acquisition, the duration of the time period since the pilot received initial training on the task, and the amount and type of flying done in the interim period since the skill was learned. Given the number of factors influencing skill retention, it is necessary to study their relative effects on specific flying skills if the effects of skill degradation are to be mitigated. Thus, if flying skills of general aviation pilots are of interest, then the performance of these pilots should be studied. Further, various types of piloting skills (e.g., cognitive, procedural, or motor) may be expected to show differential skill loss patterns and, thus, should be specifically studied.

Unfortunately, there have been very few skill retention studies that have focused on general aviation pilots. The studies that have been conducted, however, reveal that skill loss can be a problem for many of them. Seltzer (reference 22), for example, performed a study to determine the effects of calendar time since certification upon the retention of basic instrument skills by noninstrument rated pilots. (Contact flight skills were not evaluated in the Seltzer study.) While not stated explicitly in the report, it is presumed that the reason for focusing on instrument skills for these noninstrument rated pilots was to address an amendment to Federal Aviation Regulation Part 61 that requires all private pilots to demonstrate the ability to perform basic flight maneuvers solely by reference to flight instruments. Since noninstrument rated pilots cannot fly solely by reference to instruments in normal flight, they have no opportunity to exercise their instrument skills other than to practice them with another pilot in the aircraft or on an appropriate training device.

The performance of both commercial and private pilots was assessed in the Seltzer (reference 22) study. The pilots had held their certificates for periods ranging from 6 months to 9 years. In his report, Seltzer states that the results of the study indicated that there was a discernible loss of instrument proficiency since certification for the private pilots. The relationship between time since certification and skill retention was low. However, a low correlation would be expected if loss for everyone is fairly rapid. The lack of such a relationship also implies that factors other than just calendar time since certification were more dominant in determining skill retention. For example, skill retention scores did correlate positively with total instrument time since certification. The identification of such other factors, however, was confounded by certain limitations in the design of the study, which will be discussed later.

A study by Hollister, LaPointe, Oman, and Tole (reference 23) examined the retention of both contact and instrument flying skills by noninstrument rated private and commercial pilots. A wide range of proficiency was observed in the subjects. Three experience factors accounted for some 25 percent of the variance in their performance. The most dominant factor was recency, which was defined as the average rate at which a pilot had flown since certification. The logarithm of total flight time was the second most important experience factor. The logarithmic relationship was due to the finding that changes in total time were more important determinants of skill retention for pilots with low total time than for those with higher flying time accumulations (a finding of particular interest with respect to the objectives of the present study). Years since certification was the third most important experience factor.

The Hollister et al. (reference 23) study also found that, on the average, subjects received higher scores on skills employed most often in routine flights. They received the lowest average scores on skills seldom practiced, such as stalls and simulated instrument flight.

As a consequence of the research and other circumstantial evidence described above, a recent comprehensive review of human factors problems in general aviation (reference 12) concluded that flying skill degradation is one of the most critical pilot performance problems in this segment of civil aviation. Further, it was concluded that a high priority should be given to improving continuation training programs and to associated programs for recurrently assessing the performance of general aviation pilots.

At present, a number of programs exist to encourage general aviation pilots to maintain the full range of flying skills required for safe flight. Part 61.57 of the Federal Aviation Regulations specifies general currency requirements for a limited number of flight tasks (i.e., takeoffs, landings, instrument flights, and night flights). It also requires that general aviation pilots undergo a flight review every 24 months, referred to as the Biennial Flight Review (BFR). Additionally, continuation training is encouraged by FAA and industry programs that provide nominal awards for most participants.

Unlike military and air carrier aviation, however, no formal mechanisms exist whereby general aviation pilots are required to receive continuation training on specified critical skills. Indeed, recognition of the need for continuation training depends primarily on the ability of the pilots to assess their own deficiencies, and whether they seek refresher training depends on their motivation. The BFR is supposed to aid the pilot in this task, but guidelines for the conduct of this review do not specify which flying skills are to be assessed. Given the absence of such guidance, the content of the BFR varies across instructors, and some critics believe that it does not always accomplish its desired purpose (references 24 and 25).

To be efficient and effective, recurrent assessments of pilot proficiency and continuation training programs should focus on the flying skills that are critical to flight safety and most susceptible to degradation over time. As stated previously, research to aid in identifying these flying skills needs to

be specific to general aviation. Unfortunately, most of the research on flying skill retention has not been in general aviation, and the work that has been done in this segment of aviation has had certain limitations that constrain its utility. For example, neither of the general aviation studies previously cited (references 22 and 23) gathered data describing the level of proficiency that the subjects had attained during their initial training. Since the original level of skill acquisition has been found in several studies to be perhaps the most dominant single factor in skill retention (references 6 and 21), the lack of such data confounds the interpretation of the results of the general aviation studies. Subjects may have performed poorly on a given task during the retention test because (1) they did not learn to perform it well enough originally, or (2) even though original learning level was high, they failed to retain it well over time for other reasons. Additionally, neither study employed objective performance measurement instruments (subjective ratings were used), and neither assessed a broad range of flight tasks.

Given the limitations of past research and the need for information to aid in structuring continuation training, there is a need for further research to clarify the uncertainties that remain regarding the retention of flying skills by general aviation pilots. The research should identify factors influencing the way different skills are retained, including the original level of skill acquisition, and chart the influence these factors have over time. Further, since the ability of pilots to assess deficiencies in their own skills is critical to the effectiveness of current continuation training practices, this research also should assess the accuracy with which pilots can predict and evaluate their ability to perform specific flight tasks.

OBJECTIVES.

In recognition of the need for such information, the present study was designed to accomplish three primary objectives. These objectives were (1) to identify retention patterns for the skills needed to perform the various contact and basic instrument flight maneuvers and procedures that private pilots are required to master for certification; (2) to identify factors that influence retention of these skills in general and determine the specific way in which they interact to influence the retention of different skills; and (3) to develop implications for continuation training to promote skill retention among general aviation pilots. A secondary objective was to assess the ability of pilots to predict and evaluate their own proficiency.

METHOD

EXPERIMENTAL SETTING.

This study was conducted at the FAA Technical Center, Atlantic City Airport, New Jersey. All flight tasks were performed within the Atlantic City operating area. The checkpilot and aircraft were provided by Embry-Riddle Aeronautical University (E-RAU), Daytona Beach, Florida.

SUBJECTS.

Subjects were personnel employed by the FAA, and their occupations were predominantly engineering and technical. Forty-two subjects (including 4 females) began this skill retention study. All had obtained the private pilot certificate as a result of their participation in an earlier FAA-sponsored study (reference 3). Of the initial 42 subjects, 33 participated in the 8-month check, 26 underwent the 16-month check, and 21 were available for the final 24-month check. Twenty subjects (including 1 female) underwent all four checkrides. Their mean age was 34.8 years (standard deviation = 7.3 years) at the time of the 24-month retention check. Of the original 42 subjects, 26 possessed an instrument rating as a result of their recent participation in an instrument training study (reference 26). Additionally, 24 subjects acquired a multiengine rating during the retention period (reference 1). At the time of the final retention check, subjects had a mean of 162 total flight hours (standard deviation = 51 hours). They had flown a mean of 89 hours (standard deviation = 47 hours) since passing their private pilot flight test and had operated an average of 3.9 different aircraft (standard deviation = 2.0 aircraft) during that 24-month time interval. A more complete summary description of these background data is found in the RESULTS section.

CHECKPILOT.

The retention checkrides were conducted by an experienced E-RAU flight instructor with more than 3000 hours of total flight time and almost 1500 hours of dual instruction time. His responsibilities were to administer the retention checks, including the data collection instruments described below. Additionally, he recorded all in-flight performance data, having earlier been trained in the standard use of the objective data collection instrument.

AIRCRAFT.

All retention checks were performed in comparably equipped Cessna 172 aircraft, the same type as that used in subjects' private pilot training.

MEASURES ACQUIRED.

To address effectively the earlier stated research objectives, it was necessary to gather several types of performance, background, and knowledge data. The most important were data relating to in-flight proficiency. These data were acquired via the use of a Pilot Performance Description Record (PPDR) that was identical in content and sequence to that employed for the private pilot flight check. (Additional information concerning development of the PPDR is found in reference 3.) Flight tasks included in the PPDR (Table 1 and Appendix A) are the same ones that appeared in the precheck (prediction) and postcheck (evaluation) questionnaires, as well as the Private Pilot Survey, all of which are described below.

TABLE 1.--PILOT PERFORMANCE DESCRIPTION RECORD (PPDR) FLIGHT TASKS

Engine Runup and Before Takeoff Check	Magnetic Compass Turn (W-S; 270°) (Hood)
Takeoff and Departure	Unusual Attitude Recovery (Hood)
Short Field Takeoff	180° Turns (Hood)
Soft Field Takeoff	VOR Tracking (Inbound and Outbound)
Crosswind Takeoff	Forced Landing
Straight and Level Flight	Traffic Pattern (Uncontrolled Field)
S Turns Across a Road	Traffic Pattern (Controlled Field)
Turns About a Point	Go-Around
Minimum Controllable Airspeed	Landing (Uncontrolled Field)
Takeoff and Departure Stall	Landing (Controlled Field)
Approach to Landing Stall	Short Field Landing
Engine Failure During Flight	Crosswind Landing
Steep Turns (720°)	Communications (Airborne and Ground)
Accelerated Stall	Cross-Country Planning
Rate Climb (Hood)	

The PPDR is an objective in-flight data collection instrument containing a standard sequence of flight tasks to be administered in the aircraft. Tasks generally are selected on the basis of operational requirements. Each task contains a fixed sequence of clearly defined segments (where applicable) and flight measures. Objective performance indices are obtained by reference to flight status indicators, such as instrument readings, and observable visual referents (e.g., runway or horizon) outside the cockpit. Performance error is defined for each flight measure by comparing observed values or states with desired values or states at designated times or points. Desired values and tolerance levels included in the present PPDR were defined on the basis of information contained in the following documents:

FAA Private Pilot Flight Test Guide (reference 28)

Embry-Riddle Aeronautical University Private Pilot Flight Training Syllabus, developed earlier for the skill acquisition study (reference 3)

Cessna 172 Information Manual (reference 28)

The Student Pilots' Flight Manual (reference 29)

Flight Training Handbook (reference 30)

PPDR measures (such as airspeed, heading, turn radius) were recorded as either "satisfactory" or as an "error." If a given measure was observed to be within the defined tolerance (e.g., desired or assigned airspeed $\pm$ 5 knots), a satisfactory performance was recorded. If the measure was performed out of tolerance, an error was recorded for that measure. As noted previously, the checkpilot had received indoctrination training concerning PPDR recording procedures, as well as what constituted satisfactory and error performances on the various PPDR measures. Each PPDR measure and its error parameters were defined in a handbook (Appendix A) provided to the checkpilot at the beginning of the project. To ensure complete familiarization with the standard recording procedures, practice flights were made by the checkpilot both during original (certification) training and prior to the 8-month retention check. During these practice flights, the checkpilot administered each PPDR task to a member of the research team while another investigator observed from the back seat of the aircraft.

PPDR measures on each flight task were transformed into error percentages for analyses. That is, the total number of measures that were in error for a given task was divided by the total number of scored measures on that task and multiplied by 100. These error percentages (or rates) served as the primary dependent variable in assessing private pilot flight performance and skill retention. (In some data presentations that follow, the complement of error rate, i.e., the percentage of measures <u>correctly</u> performed, is used.) While error rates do not directly reflect error criticality, experience in the use of the PPDR has shown that error rate and criticality tend to be correlated positively (i.e., pilot subjects who make a large number of errors tend to make critical errors as well).

The PPDR was administered for the private pilot checkride as well as each of the three skill retention checks. In addition, other skill and knowledge indices were taken on the private pilot and 8-month checks. One of these consisted of scores on an adaptation of the FAA Private Pilot Written Test. This test was generated by the research team and had been administered (in a different form) to all pilot subjects prior to their private pilot flight test. The test contained 60 multiple choice items selected randomly from a pool of 600 items and was scored by determining the percentage of correct responses.

Since one objective of this study was to determine how well the pilot subjects could predict and evaluate their own flight skills, two questionnaires were administered as part of the private pilot and 8-month checks. The first (prediction) questionnaire was completed by each subject just prior to his or her retention flight check. The second (evaluation) questionnaire was completed by each subject immediately following the flight check before any debriefing by the checkpilot. Each questionnaire required subjects to predict (or evaluate) their proficiency on each of the 29 flight tasks in Table 1.

These questionnaires, which are identical except for instructions, are shown in Appendix B.

Finally, just prior to all three of the retention checks, a comprehensive pilot survey was administered to each subject. This survey was designed to obtain background data relating to the subject's flying activities during the interval since obtaining their private pilot certificate. These data were necessary to allow effective interpretation of the PPDR performance data. Appendix C contains this survey.

To summarize, five major types of data were collected on each subject. They were:

1. PPDR error rates on 29 flight tasks (all three retention checks);

2. Private Pilot Survey data concerning flying activities since certification (all three retention checks);

3. scores on an adaptation of the FAA Private Pilot Written Test (8-month check only);

4. precheck (prediction) questionnaire data (8-month check only); and

5. postcheck (evaluation) questionnaire data (8-month check only).

DATA COLLECTION PROCEDURES.

Two weeks prior to each retention check, subjects were notified by letter that they should contact a designated FAA authority to schedule their retention checks. The 29 flight tasks contained in the PPDR required approximately 3 hours to administer. For the 8-month check only, it was not considered feasible to acquire all written and flight performance data during the same day, since such a procedure would have interfered with the subjects' normal job responsibilities. Therefore, two sessions were scheduled for each subject. The first session was devoted to the private pilot written test only. The second was employed to gather the remainder of the data. During the second session, each subject was required to complete the following chronological sequence of data collection activities:

1. undergo checkpilot briefing;

2. complete the Private Pilot Survey (or submit survey, if already completed);

3. complete the precheck (prediction) questionnaire;

4. prepare a cross-country flight plan;

5. undergo the flight check;

6. complete the postcheck (evaluation) questionnaire; and

7. undergo checkpilot debriefing.

For both the 16- and 24-month retention checks, subjects underwent all test procedures in a single session.

EXPERIMENTAL DESIGN.

The overall design of this study provided for multiple retention checks to be administered 8, 16, and 24 months following private pilot certification. Pilot subjects who underwent these retention checks had been certificated as part of an earlier study to determine the effects of two distributions of training time on the acquisition of private pilot flight skills (reference 3). Hence, at the beginning of the 2-year retention period, the overall training and experience level of subjects was relatively homogeneous. Further, all subjects had received their certificates within the same general calendar period (December, 1980 - August, 1981).

Objective baseline PPDR in-flight performance data were acquired on all subjects at the time of their private pilot certification. Types of data obtained during each of the retention checks were identical in nature to those acquired earlier at the time of certification, and, hence, all sets of data could be meaningfully compared. These multiple retention checks were considered necessary to define the patterns and degree of flight skill decrement for general aviation pilots with from 100 to 300 hours of experience.

As with most studies aimed at assessing skill retention levels over extended time periods, it was not possible to control subjects' activities and experience during the 2-year retention interval. How much or how often subjects flew, the type of flying (e.g., training, pleasure, business) they undertook, if any, after receiving their private pilot certificate, and other flying-relevant activities would likely affect skill retention. Thus, several flight experience measures were acquired on each subject via the Private Pilot Survey (Appendix C) at the time of each of the three retention checks. These experience measures were then used to aid in interpretation of subjects' proficiency loss.

This retention study, as initially conceived during subjects' private pilot training, employed a 2 x 4 repeated measures design. That is, the retention performance of subjects trained under one or the other of two private pilot training tracks was to be assessed by flight checks administered at four points over a 2-year time interval. (The two private pilot training programs differed essentially in the amount of calendar time involved, one being about 3 months in length, while the other was about 6 months [reference 3].) The first (baseline) flight check was to occur just prior to private pilot certification, with the remaining three (retention) checks occurring 8, 16, and 24 months after certification.

The study, as carried out, employed four flight checks conducted at the above designated times. However, the original two-group design underwent

substantial modification because of differences in subjects' flying activities. Due to these differences, comparisons between the original two groups trained over different amounts of calendar time no longer were meaningful. The differences were introduced as a result of subjects' differential assignment to other FAA flight training programs. Specifically, some subjects underwent approximately 65 hours of instrument and multiengine training (references 1 and 26) during the retention interval, while other subjects had no interpolated training whatsoever. The majority of flight time acquired by the subjects over the retention interval occurred as a result of such interpolated training. Thus, the experimental design evolved into one in which comparisons were made of the skill retention levels of the subjects who underwent interpolated training during the 24-month interval versus those subjects who did not. This comparison was useful from an operational standpoint, since it is known that many "real-world" private pilots continue to pursue additional training after certification while others do not.

A second performance comparison was derived from an examination of <u>when</u> the interpolated training was received relative to the retention checks. This comparison was between two training subgroups, one of which received most of their instrument training before the 8-month check, and the other of which received most of their instrument training after the 8-month check. Thus, the skill retention of these two subgroups and that of the no-training subgroup was compared, not only for the 8-month check, but also for the 16- and 24-month checks.

To summarize, the flight performance and skill retention of three groups of subjects were examined at private pilot certification and periodically during a 2-year period thereafter (i.e., at the 8-, 16-, and 24-month points). Two subject groups underwent interpolated training (and acquired flying time attendant thereto), while the third group did not undergo such training. The interpolated training groups differed as to <u>when</u> they received interpolated training (i.e., one group mostly before the 8-month retention check and the other group mostly after that check). The analyses, therefore, focused not on correlations between subjects' flight times and their corresponding proficiency loss, but rather on whether and when interpolated training occurred and the effects of such training on retention performance. The following section describes these and other results bearing on the skill retention patterns observed over the 2-year postcertification interval.

RESULTS

FLIGHT EXPERIENCE DATA.

Performance and written data were analyzed for all three retention checks relative to private pilot checkride performance. Descriptive data on subjects' flight experience during the retention interval are presented in Table 2 to provide a general context for interpreting the nature and degree of proficiency loss to be described. Table 2 data show experience levels at the time of the 24-month retention check for the 19 subjects who underwent all

three retention checks. (An additional 6 subjects underwent two of three retention checks, while another 8 subjects took one retention check.) As earlier noted, the majority of flying experience acquired by subjects during the 2-year interval occurred in conjunction with their participation in other FAA-sponsored training research projects. Specifically, subjects who did not participate in these projects accumulated virtually no additional flying experience during the retention interval, and participants in the projects had little flying experience other than that acquired in conjunction with their involvement in the other research projects.

The recency statistic (Table 2) indicates that at the time of the 24-month check, a mean of more than 5 months had elapsed since subjects had flown. Only three subjects had flown within the last 30 days at the 24-month point. Thus, most of the subjects' additional flying experience had accrued during the initial 12 months following private pilot certification.

TABLE 2.--SUBJECTS' FLYING ACTIVITY DATA AT THE TIME OF THE 24-MONTH RETENTION CHECK (N = 19)

	MEAN	SD
Total Flight Time (Hours)	162.3	51.7
Recency (Days Since Last Flight)	157.0	98.1
FLIGHT EXPERIENCE SINCE PRIVATE PILOT CERTIFICATION		
Flight Time (Hours)	89.1	46.8
Instrument Training (Hours)	46.4	14.1
Multiengine Training (Hours)	14.8	6.2
Hood Time (Hours)	42.1	15.3
Dual Time (Hours)	64.4	35.1
Simulator Time (Hours)	29.2	22.6
Cross-Country Time (Hours)	34.7	30.0
General Aviation Aircraft Passenger Time (Hours)	10.9	27.1
General Aviation Aircraft Types Flown (Number)	3.9	2.0

CLASSIFICATION OF GROUPS BY FLIGHT EXPERIENCE.

Preliminary analyses revealed that overall retention performance was markedly influenced by the occurrence of instrument training. The amount of training and when it occurred were therefore used to classify subject groups for the majority of the analyses of performance data. Specifically, subjects were grouped according to whether they received most of their instrument training before the 8-month check (Group A), most of their instrument training after the 8-month check (Group B), or whether they received no instrument (or multiengine) training at all (Group C). (Groups A and B received approximately 48 hours of instrument training. Of the subjects comprising Groups A and B, 25 of 26 also underwent multiengine training. This training was brief [approximately 15 hours] and occurred during a relatively homogeneous time between the 8- and 16-month checks. Thus, the time when instrument training occurred was the principal differentiating factor between Groups A and B.) Groups A, B, and C contained 11, 15 and 10 subjects, respectively, at the time of the private pilot check. (Of the original 42 private pilot subjects, 6 did not participate in any of the retention checks.)

Group A accumulated a mean of 40.1 hours of instrument training during the initial retention period before the 8-month check. Group B's instrument training mainly occurred between the 8- and 16-month checks. Thus, Group B had a mean of only 9.3 instrument training hours prior to the 8-month check. As will be seen, this difference in instrument training significantly affected the performance of the two groups.

Figure 1 shows the flight times accumulated by each of the three groups at the point at which they underwent their retention checks. Note that the times depicted are those acquired only for the 8 months preceding each retention check (i.e., times are not cumulative). Most of Group A's total time occurred during the interval between certification and the 8-month check, and, by contrast, most of Group B's total time was acquired between the 8- and 16-month checks. Further, more than one-half of that time for Groups A and B resulted from instrument training. Both groups essentially stopped flying after their multiengine training, which was completed just prior to the 16-month check. This cessation of flying activity for Groups A and B is reflected in the 16-24 months data shown in Figure 1. It also can be seen that Group C's flying times were low over the entire 24-month retention interval.

Points made earlier are clearly apparent in Table 2 and Figure 1: (1) most of the flight experience acquired by subjects was in conjunction with interpolated training; (2) substantial variability occurred among the three groups with regard to flying activities during the retention period; and (3) subjects had little or no recent, relevant experience when they underwent the 24-month retention check.

FLIGHT SKILL RETENTION AMONG GROUPS.

Figure 2 presents group flight performance curves across flight checks. The data shown here are in terms of percentage of measures correctly performed,

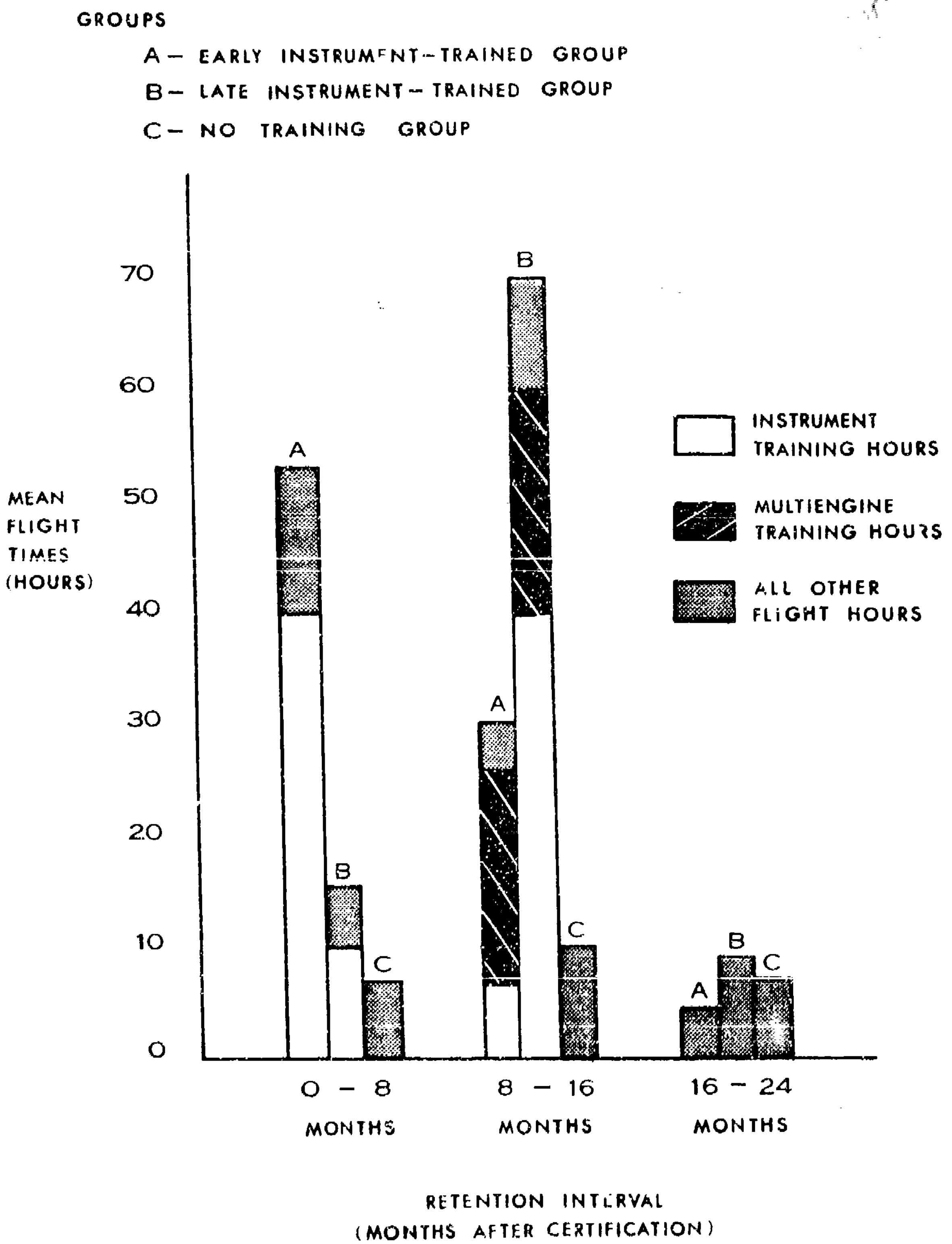


FIGURE 1.--MEAN FLIGHT TIMES OF THE GROUPS BY 8-MONTH RETENTION INTERVAL.

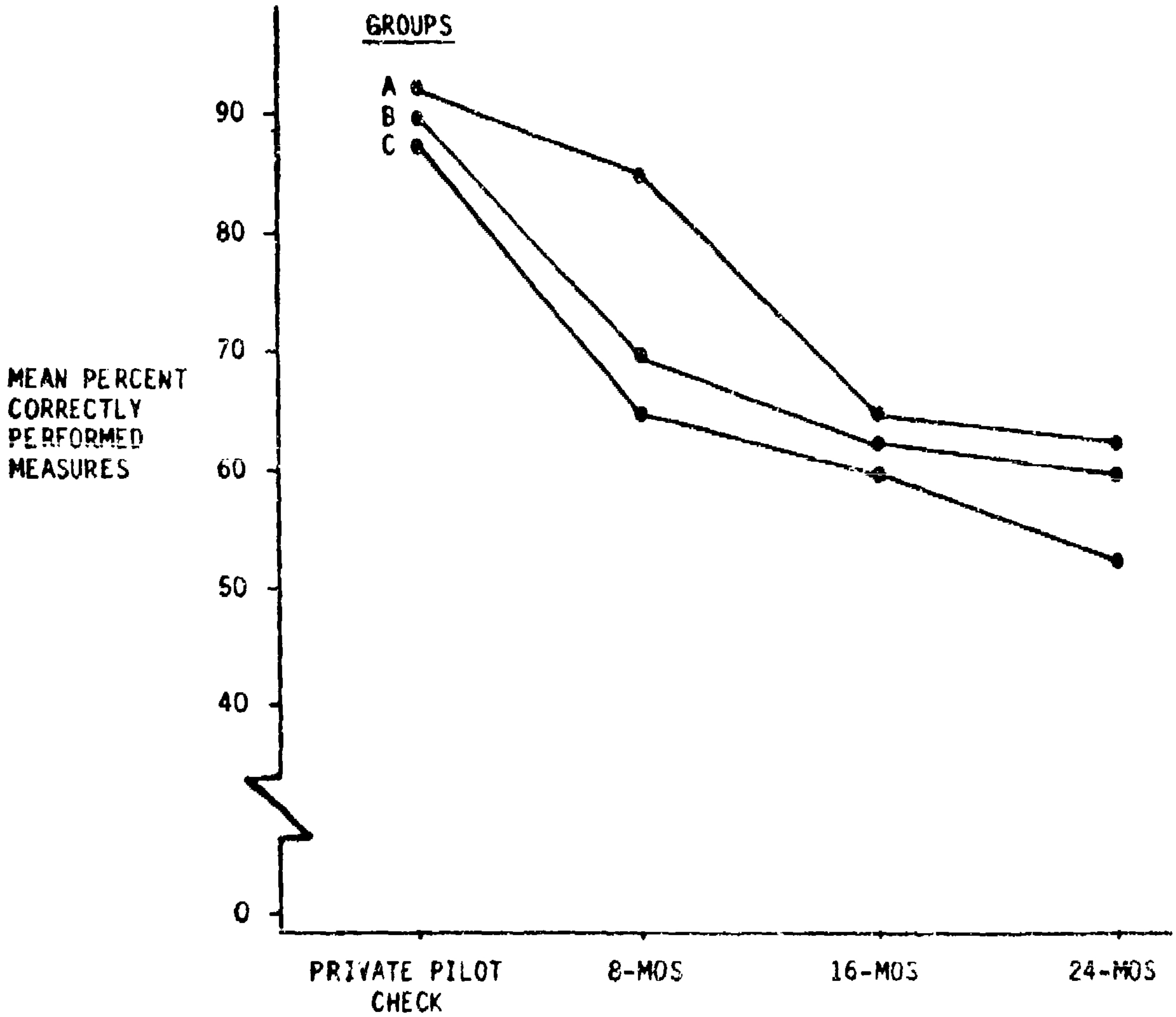


FIGURE 2.--MEAN PERCENT CORRECTLY PERFORMED MEASURES BY GROUPS ACROSS FLIGHT CHECKS.

i.e., the complement of error percentage. General decrement in performance is apparent for all groups as represented by the decreases in percentage of correctly performed measures over time. However, the pattern of the decrement is group-specific and requires further elaboration.

Each data point in Figure 2 represents all subjects within a group who underwent a given flight check. It should be noted that proficiency declined for each group from any given flight check to the next.

To determine the significance of decrement, statistical tests were performed. Correlated t tests were computed separately for each group's skill decrement across flight checks. That is, Group A's performance on the private pilot checkride was compared with its own performance on the 8-month check. Group A's 8-month performance was compared with its 16-month performance, which, in turn, was compared with its 24-month performance. These within-group statistical comparisons also were performed for flight data acquired on Groups B and C. Table 3 presents the results of these analyses. The numerical values in the table represent the increase (or in one instance, decrease) in PPDR error rate (i.e., skill loss) for pairs of designated flight checks, the number of subjects (N) whose performance was examined on both of those flight checks, and the statistical significance (p), if any, of the proficiency loss. For example, Group A (11 subjects) showed an increase in error rate of 5.8 percent from the private pilot check to the 8-month check, and this increase (i.e., skill loss) was statistically significant. Group A again showed a statistically significant skill loss from the 8- to the 16-month check, but the loss between the 16- and 24-month checks was not statistically significant (ns). Table 3 depicts sets of data that are slightly different in nature from the purely descriptive data in Figure 2. Specifically, data points in Figure 2 represent the total number of subjects in each group who underwent a designated flight check. However, numerical values in Table 3 represent only the number of subjects who underwent both of a given pair of flight checks. Thus, Ns comprising the Table 3 data were in some cases smaller than those for Figure 2, and the means differed.

TABLE 3.--WITHIN-GROUP SKILL LOSS ACROSS FLIGHT CHECKS

GROUP	PPC-8	N	p	8-16	N	p	16-24	N	p
A	5.8	11	<.01	21.5	8	<.001	4.5	6	ns
B	20.3	15	<.001	8.9	12	<.05	1.3	11	ns
C	26.6	7	<.001	(1.5)	4	ns	(N too small)		

PPC: Private Pilot Checkride
8, 16, 24: 8-, 16-, and 24-Month Flight Checks

There are several noteworthy aspects of the data in Figure 2 and Table 3. First, with respect to all three groups, proficiency loss was substantially curvilinear over the 24-month retention interval. That is, for all but the A group who received interpolated training just before the 8-month check, most of the skill decrement occurred during the initial 8 months, a moderate decrement during the next 8-month interval, and a negligible (and statistically insignificant) decrement during the last 8-month period. Group A lost relatively little between the private pilot and 8-month checks, but had a rapid loss between the 8- and 16-month checks, a finding consistent with the pattern of rapid loss in the period following training for the other two groups. As such, the Figure 2 curves depicting performance decrement for the three groups, particularly for Groups B and C, are very similar in form to the classical "forgetting curve" described in the psychological literature. It should be noted, however, that these data reflect total or overall performance on these flight checks, and that the individual tasks involved may show quite different and idiosyncratic trends.

Second, the data suggest that Group C experienced virtually all of its skill loss during the first 8 months, while the early loss for Groups A and B was mitigated somewhat by the additional training they received during the first 16 months. The performance of Group C during the final 8 months could not be meaningfully compared statistically because of the small number of subjects involved. Hence, the performance decrement shown in Figure 2 for Group C during that period should be interpreted with caution.

Third, and perhaps most important, the effects of the different points at which instrument training occurred for Groups A and B can be seen in the data. Group A began its instrument training earlier than Group B and had some 40 hours of such training (Figure 1) completed just prior to the 8-month retention check (at which point Group B had just begun its instrument training). Skill decrement was relatively less for Group A than for Group B at the 8-month check, likely reflecting the recency of Group A's interpolated training. In contrast, while Group B received considerably more interpolated training between the 8- and 16-month checks than did Group A, it did not work to Group B's relative advantage. This likely resulted from the fact that this training occurred soon after the 8-month check, but relatively <u>long before</u> the 16-month check.

It appears that the departure of Group A from this typical forgetting curve is entirely due to the interpolated training that it received just prior to the 8-month check. One test of this hypothesis consisted of assessing the error rates of the two groups on five basic instrument-related flight tasks contained in the PPDR. These were VOR Tracking and four tasks performed under the hood: Rate Climb, 180° Turn, Magnetic Compass Turn, and Unusual Attitude Recovery. If Group A's instrument training just prior to the 8-month check benefited it on that check, this should have been particularly apparent in the form of lower error rates on the above tasks relative to Group B. Examination of mean error rates on the tasks confirmed this hypothesis. Group A's increase in error rates from the private pilot check to the 8-month check on the five instrument tasks averaged less than 3 percent (their performance actually improved on two of the tasks), while Group B's increases in error

rates on these tasks averaged 19 percent. A clear advantage is therefore shown for Group A on these tasks, and the advantage might have been greater if not for the brief period of instrument training undergone by Group B just prior to the 8-month check.

Even stronger support for this hypothesis comes from an examination of skill loss for the two groups during the second 8-month interval (8-16 column in Table 3). Group B, which underwent approximately 40 hours of instrument training during this interval, exhibited relatively less decrement than Group A on the 16-month check, an almost exact reversal of the effect for the 8-month check. Group A then experienced, at the 16-month point, a major skill decrement that ostensibly would have occurred during the initial 8 months following certification had it not received the majority of its instrument training just prior to the 8-month check. For combined groups, the correlation between instrument training hours and errors on the 8-month check was -.74. That is, greater instrument training experience was, to a substantial degree, associated with fewer errors (i.e., less skill decrement). Another way to state this is that over one-half (54 percent) of the performance variance in the 8-month check error rates can be attributed to the incidence of instrument training during that interval.

An analysis also was performed on flight tasks that were assessed on each retention check but were not included in the instrument training curriculum (reference 26). This was done to determine whether the earlier instrument training taken by Group A exerted positive 8-month retention effects on other kinds of tasks. Nine tasks were identified that were not practiced during instrument training. These were: Soft Field Takeoff, S Turns Across a Road, Engine Failure, Takeoff and Departure Stall, Accelerated Stall, Forced Landing, Traffic Pattern (Uncontrolled Field), Landing (Uncontrolled Field), and Short Field Landing. (While these are predominantly contact tasks, some contact tasks such as normal takeoffs and landings are nevertheless routinely performed as part of any instrument training program.) If the benefits of instrument training extend to other (non-instrument) flight tasks, Group A should have lower error rates than Group B on the above tasks. Again, the analysis strongly supported the beneficial effects of Group A's earlier instrument training for alleviating skill decrement. Group A's error rates were lower than those of Group B on all nine tasks, and the differences were statistically significant on six of them.

These analyses suggest that flight skills decline rather rapidly if not practiced, and that practice on certain sets of tasks may transfer positively to other task sets. In the present case, tasks practiced in conjunction with instrument training (i.e., instrument tasks) enhanced performance on predominantly contact-oriented tasks as well. Neither of these conclusions is surprising in view of the literature documenting the beneficial effects of early instrument training (references 31 and 32), and studies concerned with skill retention (references 6, 7, and 21).

Due to the observed differences in amount of decrement among groups, significance of differences between groups was assessed via independent t tests. As can be determined from Table 4 data, Group A experienced significantly less

(p < .001) decrement in their flying skills during the initial 8-month interval following certification than did Group B, whose skills declined appreciably during this interval. In contrast, Group A's skill decrement was significantly greater (p < .01) than Group B's for the 8- to 16-month interval. Differences between the two groups for the 16- to 24-month interval were not statistically significant.

TABLE 4.--BETWEEN-GROUP SKILL LOSS COMPARISONS
(t TESTS) OVER THE THREE RETENTION INTERVALS

GROUP COMPARISONS	PPC-8			8-16			16-24		
	t	N	p	t	N	p	t	N	p
A versus B	4.01	25	p <.001	3.20	19	p <.01	0.69	16	ns
B versus C	1.34	21	ns		*			*	
A versus C	6.26	17	p <.001		*			*	

*Insufficient number of subjects in Group C for reliable comparisons.

Group C's skill loss was significantly greater (p < .001) than Group A's for the first 8 months, but was not significantly greater than Group B's. Notice in Figure 1 that the flying times for both Groups B and C were low as compared to Group A for this time period. While the number of Group C subjects who participated in the final two retention checks was considered too small for reliable statistical comparisons, Figure 2 data indicate that most of the skill loss documented for Group C had occurred by the initial (8-month) retention check.

The above data provide additional evidence of the positive effects of instrument training on skill retention. Further, the lack of a significant difference between Groups A and B in skill decrement for the later checks indicates that the impact of instrument training dissipated rapidly in the absence of other (nontraining) experience. Additional flight checks would have helped to define asymptotic levels of skill loss for the three groups. However, asymptotic trends are apparent in Figure 2.

RETENTION OF SPECIFIC TASK SKILLS.

With regard to proficiency loss for specific flight tasks, it was not considered feasible to use performance data from the 8-month retention check for statistical analyses. This was due to the extreme differences that occurred among subjects with regard to their experience during the initial retention interval. In effect, for Group A, and to some extent Group B, the 8-month check did not constitute a retention test for what was learned during private

pilot training as much as a test of training in progress. Thus, the only reasonable means for making statistical comparisons of specific task skill retention was the change from the private pilot certification check to the 16- and 24-month retention checks.

As with analyses for combined tasks, the measure used to assess skill loss on separate tasks was PPDR error rate (i.e., the percentage of errors occurring on each flight task across all standardized flight checks). Two tasks, Traffic Pattern at Controlled Field and Cross-Country Planning, were excluded from the analyses because of data anomalies. (For Traffic Patterns at Controlled Fields, not enough cases were available for meaningful analyses. Cross-country Planning showed highly irregular error patterns across flight checks.)

Table 5 shows the mean percentages of correct performance across flight checks for the 27 flight tasks analyzed. Figure 3 depicts the same measure for combined tasks across flight checks (including the 8-month check). (While performance data from the 8-month check were not used in statistical comparisons, they are included in Figure 3 and Table 6 for descriptive purposes only.

SKILL LOSS ON FLIGHT TASKS AT 16 MONTHS. All flight tasks considered, the mean PPDR error rate (and standard deviation) on the private pilot flight check was 3.9 percent (6.9). The 16-month retention check produced a mean error rate (and standard deviation) of 38.1 percent (15.3). The mean (and standard deviation) for overall skill loss, as defined by error rate increments across the 16-month interval was, therefore, 29.2 percent (11.1). Such loss is statistically reliable ($p < .01$). Error rates increased for all except 1 of the 27 flight tasks assessed. That task, Engine Runup and Before Takeoff Check, was the only one that involved the use of a checklist. Thus, if subjects could remember to consult the checklist (all did on both flight checks), error-free performance was virtually assured.

The upper portion of Figure 4 shows the flight tasks that underwent the greatest absolute decline in performance (as represented by mean increase in error rate) during the 16-month interval. (As previously noted, individual task analyses were not made at the 8-month check point because of subject experience variability.) The mean skill decrement for these six tasks was 42.8 percent. Flight tasks that demonstrated the least amount of absolute decrement are shown in the lower portion of the figure. The mean decrement over the 16-month interval for these five tasks was 6.8 percent.

It was reasonable to presume that the substantial difference in skill loss that characterizes the two groups of flight tasks might be partially attributed to how frequently they were performed during the retention interval and, perhaps, to their level of difficulty. This hypothesis was generally supported by analyses of survey data. Survey data indicated that high skill loss tasks were performed, on the average, during only approximately 30 percent of subjects' flights over the 16-month retention interval, while low skill loss tasks were performed during approximately 70 percent of those flights. (Survey data indicated that the mean number of flights taken by subjects

TABLE 5.--MEAN PERCENT CORRECTLY PERFORMED MEASURES FOR EACH FLIGHT TASK ACROSS FLIGHT CHECKS

TASKS	PRIVATE PILOT	FLIGHT CHECK 8-MOS.	16-MOS.	24-MOS.
1. Engine Runup/Before Takeoff Check	100	98	100	94
2. Takeoff and Departure	95	74	64	60
3. VOR Tracking	79	68	48	50
4. Straight and Level	72	74	76	66
5. Minimum Controllable Airspeed	83	62	37	39
6. Takeoff and Departure Stall	99	77	79	71
7. Approach Stall	98	84	80	76
8. Steep Turns	79	54	51	38
9. Accelerated Stall	90	51	52	57
10. Engine Failure During Flight	92	88	67	77
11. Forced Landing	95	74	67	76
12. Traffic Pattern (Uncontrolled Field)	89	70	52	56
13. Landing (Uncontrolled Field)	94	68	55	51
14. Short Field Takeoff	95	75	56	56
15. Short Field Landing	90	67	54	51
16. Soft Field Takeoff	94	80	65	61
17. Crosswind Takeoff	93	89	53	75
18. Crosswind Landing	93	81	58	63
19. S Turns Across a Road	88	54	53	41
20. Turns About a Point	83	52	52	41
21. Rate Climb (Hood)	84	56	62	38
22. Magnetic Compass Turn (Hood)	74	51	40	33
23. Unusual Attitude Recovery (Hood)	97	66	70	66
24. 180° Turns (Hood)	90	79	63	52
25. Go-Around	100	90	85	78
26. Landing (Controlled Field)	94	68	65	54
27. Communications	100	93	87	74

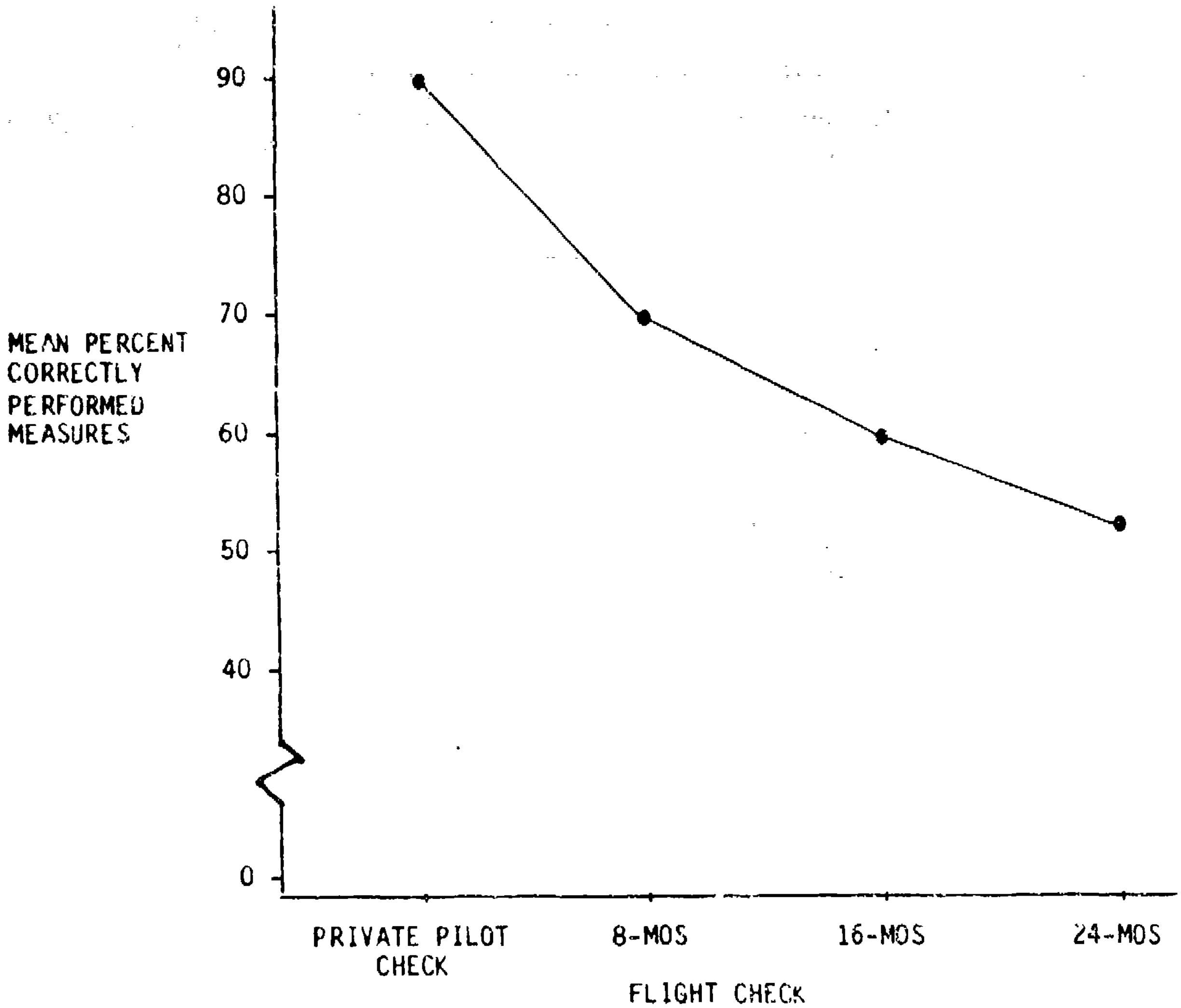


FIGURE 3.--MEAN PERCENT CORRECTLY PERFORMED MEASURES FOR COMBINED FLIGHT TASKS (ALL GROUPS COMBINED: N = 27) ACROSS FLIGHT CHECKS.

TABLE 6.--COMPOSITE SKILL LOSS FOR FLIGHT TASKS OVER THE 2-YEAR PERIOD (LOWEST RANK = GREATEST SKILL LOSS)

1. Landing (Uncontrolled Field)
2. Traffic Pattern (Uncontrolled Field)
3. Short Field Landing
4. Accelerated Stall
5. Steep Turns
6. S Turns Across a Road
7. Turns About a Point
8. Rate Climb (Hood)
9. Magnetic Compass Turn (Hood)
10. Minimum Controllable Airspeed
11. Short Field Takeoff
12. Crosswind Landing
13. Landing (Controlled Field)
14. VOR Tracking
15. Crosswind Takeoff
16. 180° Turn (Hood)
17. Normal Takeoff and Departure
18. Soft Field Takeoff
19. Unusual Attitude Recovery (Hood)
20. Takeoff/Departure Stall
21. Forced Landing
22. Straight and Level
23. Approach Stall
24. Communications
25. Engine Failure
26. Go-Around
27. Engine Runup/Before Takeoff Check

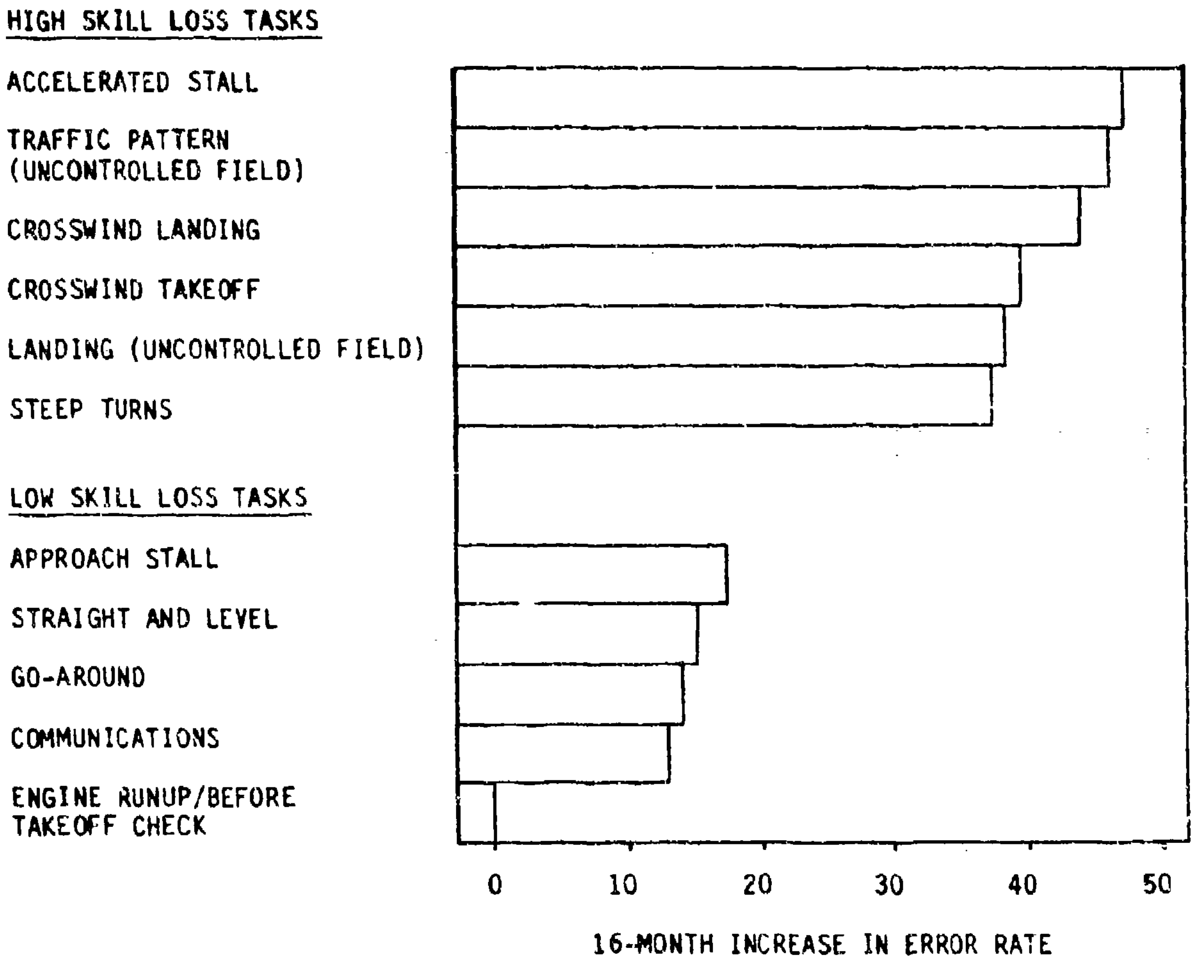


FIGURE 4.--FLIGHT TASKS EXHIBITING GREATEST AND LEAST ABSOLUTE 16-MONTH SKILL LOSS.

during this 16-month interval was 41.2.) The data that could most meaningfully be brought to bear on the question of task difficulty and its effect on 16-month retention were the maneuver difficulty ratings issued by subjects at the time of their private pilot certification flight check. (Additionally, high skill loss flight tasks produced appreciably higher absolute error rates on the 16-month check than low skill loss tasks. This does not, however, indicate that the former tasks necessarily are more difficult than the latter.) High skill loss tasks were rated by the subjects as being more difficult than low skill loss tasks. On a 5-point scale, the mean rating for the former group of tasks was 3.3, while the latter group received a mean rating of 2.1.

SKILL LOSS ON FLIGHT TASKS AT 24 MONTHS. For combined tasks, the mean (and standard deviation) PPDR error rate on the 24-month retention check was 42.4 percent (16.3). This produced an overall skill loss (as defined by error rate increments) of 33.5 percent over the 24-month retention interval. Increases in error rates over the 24-month period were statistically significant ($p < .01$) for combined tasks, as well as for each task considered separately (except Engine Runup/Before Takeoff Check).

Figure 5 shows the tasks that demonstrated the greatest and least absolute amounts of skill loss over the 24-month interval. The mean decrement (private pilot check to 24-month check) for the 11 tasks that underwent the greatest absolute amount of skill loss was 44.5 percent. The eight tasks with the least absolute amount of skill loss had a mean decrement of 19.3 percent.

COMPOSITE SKILL LOSS ON FLIGHT TASKS. To determine the flight tasks that demonstrated the greatest overall decrement during the 2-year retention period, a composite ranking procedure based upon multiple criteria was generated. This was considered necessary since skill decrement on some tasks manifested itself differently over the retention interval than skill decrement on others. For instance, certain flight tasks showed a decline in performance after 16 months, but remained relatively stable thereafter, while other tasks continued to decline. Composite skill loss was derived by ranking all tasks according to each of the following three criteria: (1) error rate on the 24-month check; (2) increment in error rate from the private pilot check to the 24-month check; and (3) increment in error rate from the private pilot check to the 16-month check. The three ranks generated for each flight task were then averaged to derive a composite rank. Based on this ranking procedure, the flight tasks that exhibited the greatest and least relative amounts of skill loss are shown in Table 6. Lower ranks indicate greater skill loss. As can be seen by comparing Table 6 data with those in Figure 5, there is substantial commonality in the tasks included by the two procedures used. However, the rankings of tasks within groupings vary. Since the composite ranking procedure represents more aspects of performance, it may be a more meaningful way of characterizing high and low skill loss.

The composite rankings in Table 6 yield relative indices of the magnitude of skill loss documented for flight tasks over the 2-year retention interval.

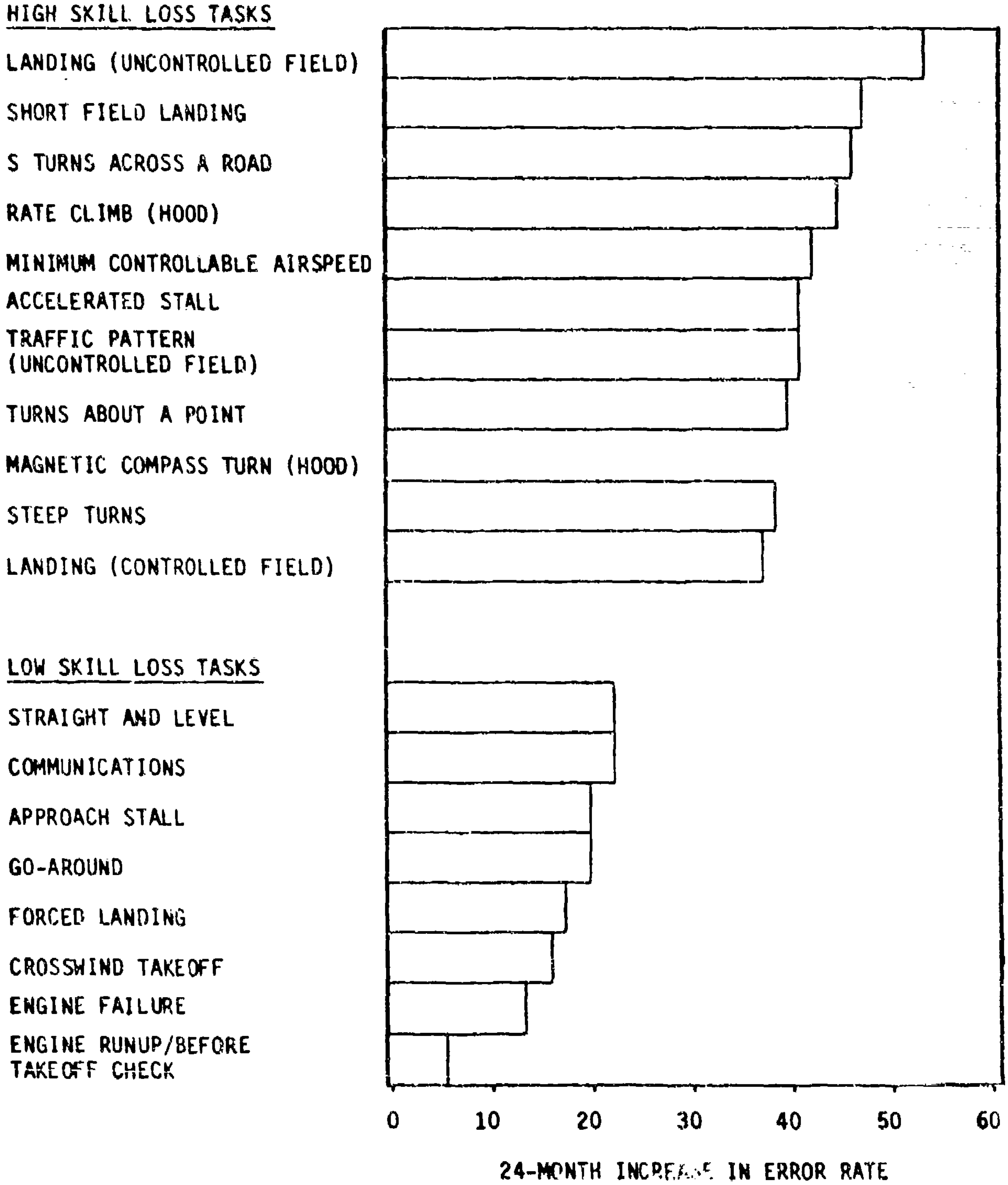


FIGURE 5.--FLIGHT TASKS EXHIBITING GREATEST AND LEAST ABSOLUTE 24-MONTH SKILL LOSS.

Another measure of interest, however, concerns the rapidity of skill loss for such tasks. From a continuation training viewpoint, useful distinctions can be made between flight tasks that exhibit virtually all of their decrement initially, and those that remain relatively more intact for greater periods of time. Table 7 lists flight tasks that exhibited relatively more rapid decrement. Thus, as compared with 24-month performance, skill decrement had been essentially completed by the 8-month point--i.e., the skill had reach asymptotic level for those tasks shown in Table 7. Flight tasks with skill loss that had been effectively completed by the 16-month check were: Minimum Controllable Airspeed, Crosswind Landing, Normal Takeoff/Departure, and Go-Arounds. All remaining flight tasks continued to exhibit decrements through the 24-month check. (To determine more precisely the function depicting rapidity of loss, multiple flight checks within each 8-month retention interval would have been necessary. For instance, monthly flight checks during the initial 8-month interval would have further differentiated among Table 7 tasks with regard to rapidity of skill loss.)

TABLE 7.--FLIGHT TASKS WITH VIRTUALLY COMPLETED SKILL LOSS AT THE 8-MONTH RETENTION CHECK

Landing (Uncontrolled Field)
Unusual Attitude Recovery
Crosswind Takeoff
Rate Climb (Hood)
Accelerated Stall
S Turns Across a Road
Magnetic Compass Turn (Hood)
Short Field Landing
VOR Tracking
Straight and Level
180° Turn (Hood)
Soft Field Takeoff
Turns About a Point
Engine Runup/Before Takeoff Check

It should be noted here that the statement that "decrement was essentially complete" by the 8-month point or the 16-month point does not imply that skill had reached the zero level. There may have been varying levels of residual skill at the 8-month or 16-month points, but no further decrement occurred after that, i.e., the decrement, whatever it might be for a given task, was completed by the 8-month or 16-month check.

WRITTEN EXAMINATION DATA.

As earlier noted, written examinations were administered to subjects just prior to the private pilot check and again at the 8-month retention check.

(Subjects were asked not to study written test materials prior to their 8-month check. Although this variable could be neither controlled nor measured accurately, it is believed that subjects had minimal study time for their retention examination.)

The respective means (and standard deviations) for written examinat[illegible]cores on the private pilot check and 8-month check were 91.5 (6.7) and 8[illegible]5). Table 8 presents means (M) and standard deviations (SD) for writte[illegible]na-tion scores for each group. Group C's scores were somewhat lower an[illegible]ore variable than scores for the other two groups on the 8-month retention check. Group A's early instrument training had no effect on their 8-month check written examination scores relative to Group B.

TABLE 8.--WRITTEN EXAMINATION SCORES (PERCENT CORRECT)

GROUPS	PRIVATE PILOT CHECK		8-MONTH CHECK	
	M	SD	M	SD
A	93.2	4.8	82.0	6.4
B	92.0	6.9	85.8	7.8
C	89.9	6.5	75.7	12.6

Scores decreased over the 8-month period for all subjects except 2, and the magnitude of decrement was statistically significant for all three groups. The correlation between written examination scores and total PPDR error rates on the 8-month check was -.29, a relationship that is not statistically significant. The rather low correlation suggests that written test scores are not valid predictors of actual flight performance.

SELF-ASSESSMENT DATA.

As a group, subjects demonstrated a moderate ability to predict and evaluate their own overall proficiency at the 8-month check. Correlating subjects' prediction and evaluation ratings with their actual performance error rates across all flight tasks resulted in rs of +.50 and +.69, respectively. These correlations represent statistically significant improvements over counterpart ratings obtained for the private pilot checkride. However, correlations of subjects' prediction and evaluation ratings with their actual performance on individual flight tasks resulted in rs ranging from -.10 to +.69, with a mean r (via Fisher z transformations) of +.36. Thus, subjects demonstrated a moderate ability to predict and evaluate their own overall performance, but were not very accurate in the case of specific flight tasks.

DISCUSSION

In order to provide a framework for integrating the somewhat diverse results of this study, they will be discussed with reference to the earlier-stated primary research objectives. The first objective dealt with the retention patterns for private pilot flight skills. The second concerned experience and other factors that influence the skill retention pattern. The third related to continuation training designed to forestall skill loss. A secondary objective was to determine the extent to which pilots are capable of predicting and evaluating their own levels of proficiency. Due to the substantial implications of the present findings for general aviation operations, the third objective area (continuation training) warrants special consideration and, therefore, will be treated separately in the following section. The other three objectives are addressed sequentially in the following discussion.

As was stated earlier in this report, while there has been a long-standing general concern with the question of flight skill retention, there has been relatively little empirical data describing the retention-forgetting function for such skills. This is particularly the case with reference to general aviation pilots. Because of various events and factors that are influencing the manner and extent to which general aviation pilots are able to maintain skill currency and proficiency, the problem of skill decay over time is of increasing concern. Further, the existing system of recurrent checks on pilot skills (the BFR) necessarily requires that the individual pilot take primary responsibility for assessing his own continuation training needs and providing for them. For these reasons, the patterns of pilot skill retention and the magnitude of skill loss over time are matters of broad concern to general aviation safety.

SKILL RETENTION PATTERNS.

Skill loss was <u>substantial</u> (PPDR error rates increased an average of 33.4 percent on the 24-month check relative to the private pilot check), <u>rapid</u> (the majority of skill loss was documented at the 8-month check except as mitigated by interpolated training), and <u>pervasive</u> (virtually every subject and every task exhibited statistically significant loss). These findings are clearly of operational significance and indicate that if skills acquired during initial training are not practiced regularly, they will undergo substantial decrement. The overall pattern of skill loss documented in this study was one characterized by relatively great proficiency loss during the initial 8 months, followed by continued, but diminishing, loss thereafter.

Flight tasks requiring a relatively high degree of integration among cognitive, procedural, and control components exhibited appreciable loss. Among these tasks were operations into and out of airports (especially under adverse conditions) and certain basic instrument maneuvers performed under the hood. In addition, ground reference maneuvers, steep turns, and accelerated stalls showed relatively high amounts of skill decrement. These latter maneuvers, while not typically practiced with any degree of frequency by private pilots, are included in the private pilot curriculum because their execution involves

practice and reinforcement of general skills that are used in a wide variety of operational flight tasks. One of these general skills is the ability of the pilot to control the aircraft in precisely the desired manner (i.e., to make the aircraft do what one wants it to do). Another is to exercise planning and judgment such that unexpected or stressful events are minimized (i.e., staying "ahead of the aircraft"). From a continuation training standpoint, the interest should be in how these skills can best be maintained (or upgraded), and in how they should be practiced and assessed. The final section of this report discusses these and other factors relating to continuation training for private pilots.

To summarize the findings relative to the pattern of flight skill retention, then, it is clear that skill loss is a general phenomenon that will affect substantially all general aviation pilots in significant fashion if skills are not practiced. Thus, the skill retention "problem" among general aviation pilots is confirmed to be a substantial one, and serious thought should be given by the FAA to means of managing or alleviating this problem.

EXPERIENCE FACTORS AFFECTING SKILL RETENTION.

The occurrence of interpolated instrument training was the only experience/background factor that appeared to have consistently benefited skill retention patterns. The pattern of loss varied with the time at which the interpolated training occurred, but overall skill loss assessed at 24 months was substantial and definitely would be of concern from the standpoint of operational safety, regardless of whether subjects had undergone training since certification. The effect of such training was to delay skill decrement but not to prevent it, since beneficial interpolated training effects were documented for one group of subjects (Group A) on the 8-month retention check and for another (Group B) on the 16-month check. Subjects had virtually no recent flying experience (in connection with training or otherwise) at the time of the 24-month check, and their performance decrement appears to have been substantially complete by that time.

No appreciable relationships were found between subjects' scores on written examinations (or other background data) and their actual flight performance. Written examinations, as presently administered by the FAA, are not performance oriented. That is, they are not designed to assess the pilot's understanding of the requirements for executing specific flight tasks and missions. Rather, the examinations tend to tap the pilot's theoretical knowledge of general content areas. Thus, this lack of relationship to flying performance is not surprising.

While none of the background and experience variables (other than interpolated training) was found to relate to flight performance and retention, some caution should be exercised in generalizing this finding to the broader general aviation pilot population. It should be kept in mind that the sample of subjects in this study was not selected randomly from among the general aviation population. Further, the subjects were relatively homogeneous with respect to most flight experience variables. Thus, it is possible that some of the experience factors examined might show a different relationship to

flight performance and skill retention among a broader sampling of general aviation pilots. Nevertheless, the fact that no significant relationships were found, except for interpolated training, suggests that use of any such indirect indices of pilot skill (e.g., total hours, written test scores, etc.) to assess retention is questionable at best, and may be totally misleading at worst.

PILOTS' SELF-ASSESSMENTS.

Pilots demonstrated a moderate ability to predict and assess their own overall performance. This finding is somewhat encouraging for continuation training applications, in that those who would be willing to undergo such training to refresh or upgrade certain flight skills must first recognize that a problem exists. The prediction and evaluation ratings indicated some such degree of skill decrement recognition by subjects. However, for specific flight tasks, their prediction and evaluation ratings failed to show any relationship to actual PPDR errors. The lack of such a relationship is of ultimate concern from the standpoint of operational safety, since it suggests that the individual pilot is not able to diagnose specifically his own continuation training needs.

As noted, the viability of the present system of identifying and providing for continuation training needs rests, in considerable degree, upon the ability of the individual to make such self-assessments and to institute appropriate remedial action. Of course, there are other mechanisms that exert an influence in this area (e.g., the enforcement of minimum skill standards as a condition to aircraft rental), but for a substantial portion of the general aviation pilot population, the decisions as to the need for and nature of continuation training are still largely made by the individual pilot.

Again, whether these findings concerning accuracy of self-assessments can be generalized to the broader population of general aviation pilots can be questioned. For example, it is reasonable to hypothesize (but by no means to conclude) that more experienced pilots are better able to assess their own skills and training needs. However, the fact remains that these data strongly suggest that there are still substantial numbers of general aviation pilots whose capability to assess their own skills is suspect.

The following section contains information concerning the effective use of continuation training for addressing proficiency loss among private pilots. Included in this brief discussion are problems in defining the extent to which different types of skills degrade; the cognitive/procedural errors that were observed in the present study; general aviation continuation training as it presently exists; and some thoughts concerning ways in which continuation training could be made more effective, especially as it pertains to cognitive skill loss.

IMPLICATIONS FOR CONTINUATION TRAINING

THE GENERAL PROBLEM OF SKILL DEGRADATION.

Results of the present study strongly indicate that private pilots who do not operate frequently need continuation training to maintain or upgrade flight skills. These findings support and extend those of previous investigations of flight skill retention among general aviation pilots (references 22 and 23). Flight skills in general decline rather rapidly and extensively after cessation of flying. Further, skills for some tasks decline to a greater degree than skills for others. From a continuation training standpoint, it is important to identify the types of flight skills that extensively and/or quickly degrade since the type and content of training should be tailored to those skills.

In the present study, the flight tasks that exhibited relatively large amounts of skill loss over the 2-year retention period all are operationally critical. Their importance stems from the fact that some (e.g., landings on short runways or at uncontrolled fields) are of direct use in operational settings, while others (e.g., ground reference maneuvers) are more abstract and involve basic skills that underly the execution of the former tasks. Some (e.g., VOR tracking) are critical not only because they are required for safe flight operations, but also because skills on them degraded relatively quickly. Continuation training methods should be generated with this in mind, but to be most effective and efficient, the methods need to address, to the extent possible, the specific skills involved in performing these tasks.

IDENTIFICATION OF THE NATURE OF DEGRADED SKILLS.

Studies of pilot flight skill retention have reported that skills involving substantial cognitive/procedural components undergo relatively greater and more rapid decrement over time than control-oriented skills (references 5 and 33 through 36). To attempt to identify the types of skills that degraded in the present study, an exploratory post hoc analysis was conducted of those PPDR items on which errors were made.

For the most part, the PPDR, like other flight measurement instruments, is not designed to differentiate precisely among skills involved in the successful execution of flight tasks. Most of the measures contained in the instrument are primarily aircraft control-oriented, although it is obvious that cognitive, decisional, and procedural components contribute to maintaining the aircraft in the desired control conditions, and such components may or may not be measured and reflected in the error rate for a flight task. An example will clarify this point. A pilot may err in achieving the proper level off altitude in a takeoff and departure. The error is then recorded for the altitude measure within the level off segment of the PPDR, but the checkpilot is not certain, for example, whether the pilot (1) remembered the desired altitude, but failed to achieve it (control error); (2) forgot the desired altitude (cognitive error); or (3) forgot to stop the climb at the proper point (cognitive/procedural error). Regarding the third, and apparently most

common, difficulty, what is often missing in a skill is a clear, more or less automatic, guiding of motor actions because of degradation of cognitive monitoring as the action evolves. (As used here, "monitoring" refers to much more than the term typically includes in flight contexts. All skills, motor actions included, are guided by cognitive/perceptual processes that relate the moment-to-moment status of an ongoing action to an awareness of what should be happening at any given time. Successful monitoring requires sensitivity to any feedback or effects of an action that indicate correct performance or a need for an adjustment during an action. While information from instrument scans and out-the-window scenes is important for monitoring, it is also necessary to have a proper sense of timing of actions which requires a clear cognitive pattern of how components of an action relate to each other.) The pilot may know what is to be done, but not when in the sense of maintaining coordinated action.

Despite these diagnostic complexities, it is possible to identify PPDR measures that are predominantly cognitive/procedural in nature. Examples of such measures are using proper entry procedures for stalls, using proper flap settings for go-arounds or soft field takeoffs, and acknowledging and complying with all ATC instructions.

The exploratory analysis revealed that measures such as the above frequently were performed in error on the 24-month retention check. For instance, all subjects failed to acknowledge at least one ATC instruction at some point during this flight check, and 70 percent of the subjects used improper entry procedures for one or more of the stall maneuvers. Examples of other primarily cognitive errors are shown in Table 9. Thus, while clear distinctions cannot be drawn between cognitive/procedural errors and control errors on the basis of measures contained in the PPDR, it is possible that much (and probably most) of the skill loss documented in the present study is attributable to forgetting of task performance requirements as they evolve stage by stage during the task.

CONTINUATION TRAINING NEEDS.

Flying is a psychomotor process. That is, pilots must attend to relevant cues, recognize such cues when they occur, decide upon appropriate responses to those cues, and respond accordingly. The response (or motor) aspects of the process are generally well learned during initial training, and although they may deteriorate somewhat over time, brief intermittent practice in the aircraft (monitored by a checkpilot) or on a training device of appropriate control fidelity usually is sufficient to regain them. The greater concern is with the perceptual/cognitive (or mental) processes related to cue maintenance required for successful monitoring of actions. It is effective monitoring processes that appear to be significant factors in the preponderance of general aviation accidents that are attributed to "pilot error" (reference 12).

Cues are formed when pilots attach meaning or significance to perceptible internal or external objects or events (references 37 and 38). For example, on the downwind leg of a traffic pattern, a point that is approximately

TABLE 9.--EXAMPLES OF PREDOMINANTLY COGNITIVE/PROCEDURAL ERRORS ON THE 24-MONTH RETENTION CHECK

ERRORS	PERCENTAGE OF SUBJECTS COMMITTING ERRORS
Cross-Country Planning	
• Incorrect estimation of time enroute	83
• Inability to verbalize communications requirements for change in flight plan	83
• Incorrect ETA calculation	61
• Incorrect fuel requirement estimation	52
VOR Tracking	
• Failure to identify station	83
• Failure to identify radial	39
Stalls	
• Failure to perform correct entry procedures	70
• Failure to achieve/recognize stall	48
Forced Landing	
• Poor selection of landing area	26
• Inability to verbalize correct procedures	26
Engine Failure	
• Failure to turn on carb heat	52
Uncontrolled Field Traffic Pattern	
• Incorrect entry (altitude or distance out)	65
• Failure to perform cockpit check	65
• Improper flaps or trim	30
Soft Field Takeoff	
• Failure to use rolling start	39
• Improper flaps or trim	30
Turns About a Point	
• Improper entry/exit	70
Communications	
• Failure to understand/comply with ATC messages	100
• Failure to tune correct frequency	91
• Improper use of microphone	61
Taxiing	
• Improper control positioning	95
• Improper brake/power usage	95

opposite the landing end of the runway (the 180° point) normally should serve as a visual cue for reducing power. Since the prelanding checklist should be performed prior to reaching the 180° point, performing the checklist could, through experience, serve as a mental cue for reminding (conditioning) the pilot to watch for the 180° point. Once they are remembered, the actual responses performed by the pilot in this example are relatively simple, straightforward, and easily retained over prolonged periods of time. However, as the data in Table 9 imply, the cues for making those responses are not so well retained. Thus, one of the challenges in developing and implementing effective continuation training is to provide general aviation pilots with techniques and procedures that will enable them to practice and reinforce the mental cues necessary for monitoring actions. The capability to recognize and to respond to such cues is the basis for flight skill development, and it is crucial for skill retention.

Both the general literature on skill retention and the results of the present study suggest that generation of methods to improve the retention of cognitive skills should be one of the primary objectives of continuation training. Retention is enhanced to the extent cueing structures can be maintained. Thus, continuation training should focus on the cues that are necessary for sustaining pertinent skills. Ideally, cues and their relevance for safe operations would be systematically stressed or emphasized during initial training. This would better enable pilots to attenuate irrelevant cues while attaching significance to certain relevant cues and associating them with correct responses. Unfortunately, cue development is not typically emphasized in private pilot training. Instead, cues more often are learned unsystematically through experience. The goals of continuation training should be to identify relevant cues, teach those cues if they have not already been obtained, reinforce those cues if they have been obtained, and associate them with the proper responses.

Given that pilots experience significant performance decrements over relatively short time periods, and that such decrements are at least partly cognitive in nature, methods should be sought to reduce or alleviate this type of skill loss. As has been noted elsewhere, the process of defining and implementing optimal training methods is not straightforward because of the many complexities involved (references 6, 7, and 21). Some of these complexities have been touched on in this report, but there are many more related to characteristics of the pilot (e.g., skills, motivation, physical condition, experience, recency of flight), the task (e.g., performance requirements, practice frequency), the aircraft (e.g., equipment, handling characteristics), the environment (e.g., weather, airport, traffic), and other factors. In spite of this, the most promising approach to maintaining the skills necessary for safe and efficient flight operations is through the systematic and intelligent use of continuation training techniques.

A very effective technique, and one easily employed, is mental rehearsal of what one does, step by step, in performing a task. Mental rehearsal has been shown to be highly effective not only in the retention of motor skills, but in their acquisition. (See reference 39 for a review of laboratory and applied

research on this topic.) Effectiveness requires only sufficient prior experience in the task to make cues and actions comprising each step meaningful and imaginable. (A cockpit mock-up would aid in the rehearsal.) One likely problem with skill retention by the subjects in the experiment reported here was that generally they were not personally dedicated to flying, which was evidenced by their failure to fly except during formal training. Hence, it is unlikely that they rehearsed the flight tasks mentally and seriously once training had ended. If they had, retention probably would have been better.

The present mechanism in general aviation for proficiency maintenance is the Biennial Flight Review. Part 61.57 of the Federal Aviation Regulations requires all pilots to undergo a BFR every 24 months. While there are several programs designed to encourage pilots to maintain or upgrade their knowledge and skills, the BFR is the only requirement to do so. However, as earlier mentioned, several studies have indicated that the BFR does not accomplish its intended purpose because of deficiencies in its content and administration (references 12, 24, and 25). Among these deficiencies are a lack of:

1. guidance concerning the specific skills to be assessed;

2. objective assessment criteria;

3. uniformity among instructors in the administration of the BFR; and

4. documentation of unsatisfactory BFR outcome.

Additionally, the BFR does not sufficiently address the cognitive/procedural types of skills that are rather rapidly lost during lapses in operations. Data from the present study indicate that 2-year reviews are not sufficiently frequent to upgrade flight skills lost by relatively inexperienced private pilots. The same is probably true for more experienced pilots who do not operate over prolonged time periods. In view of the above problems, effective and efficient continuation training programs are needed to maintain and upgrade safety among general aviation pilots. Following is a brief discussion of continuation training media that are potentially useful in the facilitation of cognitive skills and cue retention.

TRAINING MEDIA.

In a generic sense, cognitive training is a term used to refer to the specification and teaching of the knowledge aspects of a complex task (i.e., one involving complex interactions among perceptual, cognitive/decisional, and motor components). Various types of training media can be effectively employed in conjunction with cognitive training. These include, but are not limited to, the types of media to be discussed.

There is empirical support for the effective use of cognitive training for imparting flight skills (references 38, 40, 41, and 42). Its facilitative effects largely are derived from its role in the cue development process, because it is adaptive to the task, the aircraft, and pilots' diverse learning

styles, and because extensive use is made of feedback and guidance. Cognitive training also promotes the development of mediational processes including internal verbalization of task performance requirements, specific techniques for memorizing such requirements (termed mnemonics), and mental imagery and rehearsal.

The effective use of cognitive training calls for the task performance requirements to be carefully analyzed before implementation occurs. In addition, objectives of the training should be explicitly stated and kept clearly in mind by trainees.

In view of the pervasive role of cognitive processes in skill development and retention, the major advantages of cognitive continuation training are its relatively low cost when used with such media as slides (or other visual aids) and audio tapes (or written text); its versatility, flexibility, and ease of use as compared to fixed-base simulators or even table top trainers; its potential for upgrading skills generally; and perhaps most important, the fact that it can be self-administered by pilots, assuming that they know what their skill deficiencies are. Current disadvantages of cognitive training are its apparent inability to improve substantially degraded motor skills and the neutral or negative attitudes of the general aviation community concerning its potential training benefits.

Several types of training media are of potential benefit to general aviation pilots seeking to improve or maintain cognitive skills acquired as a result of their earlier training. Of these, the most complex are likely the high fidelity simulators employed by commercial aviation training centers. Examples of such devices are the simulators used in training pilots to operate (or transition to) business jets. Other types of devices are the GATs (1 and 2) that are used in training for a broad range of less complex aircraft. For increased portability, smaller, less sophisticated devices, such as "table top" trainers, can be used for training in aircraft of the same class. The training value of such media can be considerable when they are used optimally.

An additional type of training medium is the computer-generated image (CGI) video display. Such displays include dynamic, rapid rate-of-change representations of internal and external visual scenes as they are viewed by the pilot during various phases of flight. For example, during an approach to landing, the pilot might see external scenes such as horizon and runway, and internal scenes might include instrument indications of airspeed, altitude, engine RPM, descent rate, and heading. Pilots can practice monitoring their performance by interacting with the visual scenes via keyboards, joysticks, and other input devices. Research using CGI has shown that significant training enhancements can accrue due to the capability to introduce, emphasize, and otherwise modify visual cues for guiding the pilot through the proper execution of the task (references 43 and 44). As they decrease in cost, CGI devices offer much promise for private pilot continuation training.

More recently, software packages for microcomputers have become commercially available. Unlike the somewhat more sophisticated CGI presentations used in controlled research contexts, these software packages have not been

specifically designed to include effective training cues. They are intended primarily to serve as games, and, as such, do not presently appear to be viable continuation training media. If designed with continuation training in mind, however, or if used in a manner that exploited whatever effective cues presently are contained in these packages, they could serve to upgrade certain types of private pilot flight skills. Results of the present study suggest that new or modified designs of microcomputer software packages for continuation training purposes should concentrate on providing cues for assisting pilots in remembering the performance requirements for the flight tasks that are necessary for safely conducting a mission. Systematic research is needed to more fully address this question, but it appears that the forgetting of task performanc . quirements is a major problem in private pilot flight skill retention.

A training medium that appears to be largely underused by general aviation pilots, but one which can be effective if used seriously and intelligently, consists of photographs, slides, and mock-ups of aircraft cockpit instrumentation and external scenes. Most pilots have consulted aircraft cockpit diagrams contained in operating manuals as part of their ground school or in mentally rehearsing a procedure. Research on the use of these static media has indicated that, when used as part of a structured training program, they can be very effective and efficient (references 42, 45, and 46). However, few programs currently integrate such media into their training curricula. Training materials such as those produced by Kershner (reference 29) and others include a good selection of illustrations of both internal and external scenes, but the training benefits of such material are not being fully realized. As earlier noted, one of the factors underlying this shortcoming concerns the strongly conditioned traditional attitudes among the general aviation training community (which, of course, influence the attitudes of the pilots themselves) that emphasize the importance of airborne training and (intentionally or unintentionally) ignore the training potential of static, ground-based media. While some of the more innovative flight instructors employ these latter methods to reinforce in-flight training material, few initial training packages offered commercially include these methods in their regularly scheduled training. Further, there are no known instances of the structured use of such methods for effective continuation training. The use of static ground-based media for private pilot continuation training needs empirical investigation.

Finally, a promising approach to effective continuation training consists of the use of full mission simulation for evaluating pilots' decisions and responses to critical in-flight events. The approach uses relatively comprehensive flight scenarios (rather than discrete flight tasks) to assess pilots' reactions to such events. Although full mission simulation has most commonly been used with relatively sophisticated training devices (reference 47), a recent study (reference 48) demonstrated positive results using a GAT-1 to assess cognitive/decision-making skills. The use of a paper-and-pencil device based on the above methodology also yielded encouraging results. It was concluded in the Rockwell and Giffen study (reference 48) that, when coupled with instruments that can provide valid assessments of pilots' operational knowledge, full mission simulation can be a valuable continuation training tool.

TAILORING TRAINING MEDIA TO DEGRADED SKILLS.

Media to be used for continuation training purposes should be selected on the basis of the flight skills to be maintained or upgraded. It would make little sense, for example, to employ computer-generated image displays for upgrading complex control skills when devices with higher control fidelity are needed. On the other hand, CGI displays can be very effective for rehearsing the visual discriminations that are necessary for associating external with internal cues. The present data suggest that such discriminations undergo appreciable decrement when not practiced regularly. Similarly, it would be unnecessarily costly to employ a complex motion-based simulator solely for the purpose of upgrading simple cockpit procedures when much simpler devices would suffice.

The flight tasks exhibiting the greatest amount of composite skill loss (Table 6) in this study cannot clearly be categorized by the type of component skills predominantly involved in their successful execution. Rather, several types of skills are required to perform these tasks. It has already been shown, however, that at least part of the flight skill loss documented in this study can be attributed to cognitive/procedural errors by the subjects. The use of relatively simple training media, accompanied by mental rehearsal, may be sufficient for upgrading cognitive/procedural skills. Given that their cognitive skills are acceptable, pilots may need to sharpen their control skills via the use of somewhat more sophisticated devices. Pilots should, perhaps, be more aware than anyone of the need to increase their precision in controlling the aircraft. If continuation training is warranted, a device with appropriate control fidelity should be employed. If only gross control responses to cues arising in the cockpit need upgrading, a few hours in a GAT or even a table top trainer may be all that is required. If more precise and subtle control movements need to be sharpened, a high-fidelity simulator may be the only acceptable substitute for in-flight time. Decisions about the type of training medium to be employed should be made at least partially on the basis of the nature of the skills that are to be practiced. On the basis of the present findings, it would appear that relatively simple static training media used as part of an effective cognitive training regimen could quite effectively serve to forestall loss of many flight skills for private pilots. Should empirical research demonstrate the viability of such media for continuation training, it could be an economical way to reduce general aviation accidents involving private pilots.

Many criteria exist for evaluating the usability of cognitive (and other) training for maintaining or upgrading private pilot flight skills. These include (but are not limited to):

1. the cost of training (acquisition, conduct, and maintenance);
2. amount of training required to maintain/upgrade skill;
3. flexibility of the training for addressing various types of skills;
4. portability of the training media;

5. ease of use;

6. adaptability to a pilot's learning style;

7. cue development and reinforcement capability;

8. feedback and guidance capability;

9. performance measurement capability;

10. diagnostic capability; and

11. capability for self-administration.

Of course, the ultimate criterion for assessing the value of any continuation training medium is the extent to which skills practiced via the medium transfer to the aircraft.

CONCLUSIONS

Based on the results presented and the discussion and implications thereof, a number of general conclusions can be drawn.

1. Recently certificated private pilots who do not fly regularly can be expected to undergo a relatively rapid and significant decrement in their flight skills. Further, such decrement will affect most flight tasks that are required of the private pilot.

2. The effect of interpolated flight training is to forestall (not prevent) skill decrement.

3. Instrument training, properly conducted, can exert positive effects on the retention of both contact and instrument flight tasks.

4. Greater and more pervasive performance decrements may be expected for flight tasks that require appreciable coordination between cognitive and control skills.

5. Written test (i.e., knowledge) scores decrease significantly during the 8-month period following certification; however, written test scores are not useful for predicting actual flight performance.

6. Private pilots who do not fly frequently need periodic diagnostic assistance to help them pinpoint specific flight tasks on which they need continuation training.

7. Continuation training methods should be skill-specific and emphasize the development and reinforcement of cognitive cues.

8. An urgent need exists for the development of more effective performance criteria and of continuation training methods designed to aid private pilots in meeting those criteria.

REFERENCES

1. Childs, J. M., Spears, W. D., Shelnutt, J. B., & Prophet, W. W. Private pilot flight skill retention eight months following certification (TR 82-08). Pensacola, FL: Seville Research Corporation, May 1982.

2. Childs, J. M., & Prophet, W. W. Private pilot flight skill retention sixteen months following certification (TR 82-09). Pensacola, FL: Seville Research Corporation, August 1982.

3. Shelnutt, J. B., Spears, W. D., & Prophet, W. W. Effects of different distributions of training time on the acquisition of private pilot flying skills (FAA/CT-81/76). Washington, DC: Federal Aviation Administration, July 1981.

4. Naylor, J. C., & Briggs, G. E. Long-term retention of learned skills: A review of the literature (ASD-TR-61-390). Wright-Patterson AFB, OH: Air Force Systems Command, August 1961.

5. Sitterley, T. E. Degradation of learned skills--static practice effectiveness for visual approach and landing skill retention (Document D180-17876-1). Seattle, WA: The Boeing Aerospace Company, May 1974.

6. Prophet, W. W. Long-term retention of flying skills: A review of the literature (HumRRO-FR-ED[P]76-35). Alexandria, VA: Human Resources Research Organization, October 1976.

7. Schendel, J. D., Shields, J. L., & Katz, M. S. Retention of motor skills: A review (Technical Paper 313). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978.

8. National Transportation Safety Board. Special study of fatal, weather-involved general aviation accidents (NTSB-AAS-74-2). Washington, DC: Author, August 1974.

9. National Transportation Safety Board. Special study - nonfatal, weather-involved general aviation accidents (NTSB-AAS-76-3). Washington, DC: Author, May 1976.

10. Connor, T. M., & Hamilton, C. W. Evaluation of safety programs with respect to the causes of general aviation accidents. Volume I: Technical report. Columbus, OH: Battelle Columbus Laboratories, 1979.

11. National Transportation Safety Board. Special study - light twin-engine aircraft accidents following engine failure, 1972 - 1976 (NTSB-AAS-79-2). Washington, DC: Author, December 1979.

12. Shelnutt, J. B., Childs, J. M., Prophet, W. W., & Spears, W. D. Human factors problems in general aviation (FAA-CT-80-194). Washington, DC: Federal Aviation Administration, April 1980.

13. Goorney, A. The human factor in aircraft accidents - investigation of background factors of pilot error accidents (FPRC/Memo-224). London: Flying Personnel Research Committee, May 1965.

14. Munley, F. Commuter airline safety: An analysis of accident records and the role of federal regulations. Washington, DC: Aviation Consumer Action Project, August 1976.

15. National Aeronautics and Space Administration. NASA aviation safety reporting system: Seventh quarterly report (NASA-TM-78528). Washington, DC: Author, August 1978.

16. National Transportation Safety Board. Air taxi safety study (NTSB-AAS-72-5). Washington, DC: Author, September 1972.

17. National Transportation Safety Board. Special study - accidents involving engine failure/malfunction: U.S. general aviation, 1965 - 1969 (NTSB-AAS-72-10). Washington, DC: Author, November 1972.

18. National Transportation Safety Board. Special study - U.S. general aviation accidents involving fuel starvation, 1970 - 1972 (NTSB-AAS-74-1). Washington, DC: Author, April 1974.

19. National Transportation Safety Board. Special study - U.S. general aviation takeoff accidents: The role of preflight preparation (NTSB-AAS-76-2). Washington, DC: Author, March 1976.

20. National Transportation Safety Board. Annual review of aircraft accident data - U.S. general aviation, calendar year 1977. Washington, DC: Author, November 1978.

21. Gardlin, G. R., & Sitterley, T. E. Degradation of learned skills: A review and annotated bibliography (Document D180-15080-1). Seattle, WA: The Boeing Company, June 1972.

22. Seltzer, L. Z. A study of the effect of time on the instrument skill of the private and commercial pilot (FAA-DS-70-12). Washington, DC: Federal Aviation Administration, April 1970.

23. Hollister, W. M., LaPointe, A., Oman, C. M., & Tole, J. R. Identifying and determining skill degradations of private and commercial pilots (FAA-RD-73-1). Cambridge, MA: MIT Measurement Systems Laboratory, June 1973.

24. General Accounting Office. Improved controls needed over private pilot licensing (RED-76-65). Washington, DC: Author, February 1976.

25. Boody, P. Biennial shell game. Flying, 1980, 106(5), 79-90.

26. Holmes, C. W., & Childs, J. M. The effects of pilot experience on acquiring instrument flight skills - Phase II (FAA/CT-82/35). Washington, DC: Federal Aviation Administration, March 1982.

27. Federal Aviation Administration. Flight test guide, private pilot, airplane (Advisory Circular AC 61-54A). Washington, DC: Author, 1975.

28. Cessna Aircraft Company. Information manual, Skyhawk (model 172N). Wichita, KS: Author, 1979.

29. Kershner, W. K. The student pilot's flight manual. Ames: Iowa State University Press, 1979.

30. Federal Aviation Administration. Flight training handbook (Advisory Circular AC 61-21A). Washington, DC: Author, 1980.

31. Ritchie, M. L., & Michael, A. L. Transfer between instrument and contact flight training. Journal of Applied Psychology, 1955, 39(3).

32. Prophet, W. W., & Jolley, O. B. Evaluation of the integrated contact-instrument concept for Army fixed-wing flight instruction (TR 69-26). Alexandria, VA: Human Resources Research Organization, December 1969.

33. Mengelkoch, R. F., Adams, J. A., & Gainer, C. A. The forgetting of instrument flying skills as a function of the level of initial proficiency (NAVTRADEVCEN 71-16-18). Port Washington, NY: U.S. Naval Training Device Center, 1960.

34. Hufford, L. E., & Adams, J. A. The contribution of part-task training to the relearning of a flight maneuver (NAVTRADEVCEN TR-297-2). Port Washington, NY: U.S. Naval Training Device Center, 1961.

35. Wilson, W. B. The effect of prolonged non-flying periods on pilot skill in performance of a simulated carrier landing task (Master's Thesis). Monterey, CA: Naval Postgraduate School, September 1973.

36. Smith, J. F., & Matheny, W. G. Continuation versus recurrent pilot training (AFHRL-TR-76-4). Brooks AFB, TX: Air Force Human Resources Laboratory, May 1976.

37. Caro, P. W., Shelnutt, J. B., & Spears, W. D. Aircrew training devices: Utilization (AFHRL-TR-80-35). Wright-Patterson AFB, OH: Air Force Human Resources Laboratory, January 1981.

38. Spears, W. D. Process of skill performance: A foundation for the design and use of training equipment (TR 82-06). Pensacola, FL: Seville Research Corporation, March 1983.

39. Wheaton, G. R., Rose, A. M., Fingerman, P. W., Korotkin, A. L., & Holding, D. H. Evaluation of the effectiveness of training devices: Literature review and preliminary model (Research Memorandum 76-6). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, April 1976.

40. Flexman, R. E., Townsend, J. C., & Ornstein, G. N. Evaluation of a contact flight simulator when used in the Air Force primary pilot training program (AFPTRC-TR-54-38). Lackland AFB, TX: Air Force Personnel and Training Research Center, 1954.

41. Wood, M. E., & Gerlach, V. S. Transfer from audiovisual pretraining to a continuous perceptual motor task (AFHRL-TR-74-8). Williams AFB, AZ: Air Force Human Resources Laboratory, March 1974.

42. Smith, B. A., Waters, B. K., & Edwards, B. J. Cognitive pretraining of the T-37 overhead traffic pattern (AFHRL-TR-75-72). Williams AFB, AZ: Air Force Flying Training Division, June 1975.

43. Finnegan, J. P. Evaluation of the transfer and cost effectiveness of a complex computer-assisted flight procedures trainer (TR ARL-77-7/AFOSR-77-6). Savoy, IL: University of Illinois, Aviation Research Laboratory, 1977.

44. Lintern, G. Transfer of landing skill after training with supplementary visual cues. Proceedings of the 23rd annual meeting of the Human Factors Society. Boston, MA: Human Factors Society, 1979.

45. Prophet, W. W., & Boyd, H. A. Device-task fidelity and transfer of training (TR 70-10). Alexandria, VA: Human Resources Research Organization, July 1970.

46. Caro, P. W., Jolley, O. B., Isley, R. N., & Wright, R. H. Determining training device requirements in fixed wing aviator training (TR 72-11). Alexandria, VA: Human Resources Research Organization, April 1972.

47. Smith, H. P. R. A simulator study of the interaction of pilot workload with errors, vigilance, and decisions (NASA-TM-78872). Washington, DC: National Aeronautics and Space Administration, January 1979.

48. Rockwell, T. H., & Giffen, W. C. An investigation into pilot and system response to critical in-flight events. Volume I (Grant No. NASZ-10047). Columbus, OH: The Ohio State University Research Foundation, June 1981.

APPENDIX A

HANDBOOK FOR THE USE OF THE
PILOT PERFORMANCE DESCRIPTION RECORD (PPDR)
AND
PILOT PERFORMANCE DESCRIPTION RECORD

This appendix contains a copy of the handbook used to standardize the check-pilot in the use of the Pilot Performance Description Record (PPDR). The handbook gives instructions concerning the mechanics of administering the PPDR and defines performance measures used in the 29 PPDR flight tasks. Also contained in this appendix is a copy of the PPDR that was used to record subjects' in-flight performance for the private pilot checkride and the 8-, 16-, and 24-month retention checks. Procedures as to how the PPDR was used are described in the METHOD section of the report. Table 1 of that section lists the flight tasks contained in the PPDR.

HANDBOOK FOR THE USE OF THE
PILOT PERFORMANCE DESCRIPTION RECORD (PPDR)

I. Purpose

A. General - to provide a method of clearly describing and documenting student pilot performance

B. Specific - to provide objective performance data for evaluating Contact performance of students in various training tracks.

II. Guiding Principles

A. to obtain a maximum of descriptive and specific judgmental information with a minimum of in-flight marking

B. to be made compatible with existing FAA and E-RAU checkride procedures

III. PPDR Characteristics and General Utilization

A. Each flight task in this PPDR has been analyzed and discussed with E-RAU personnel to determine its fundamental components. The analyses provided the basis for the development of descriptive and judgmental scales on which each performance component, such as direction, attitude, power, and flight path, could be quickly described by the checkpilot.

B. This PPDR includes a sample of the flight tasks described in the FAA flight test guide on which proficiency must be demonstrated to pass the checkride for the Private Pilot license. This PPDR is intended to provide descriptive data for this sample only. Administration of this PPDR should not restrict or constrain the checkpilot's usual checkride prerogatives. In particular, in-flight safety must not be jeopardized, although the sequence of PPDR tasks should be standardized as described in E. below. The performance description resulting from this PPDR is considered to be as complete as can be obtained efficiently by manual recording during a single flight period.

C. In any data collection effort, reliability (meaning consistency or repeatability of test result), and validity (meaning measurement of that which is intended to be measured) are desirable goals. One necessary factor in achieving high levels of reliability and validity is standardization of the test sample, test conditions, and methods of data recording. The standardization of the flight test sample and the methods for administering and evaluating it is the aim of the PPDR.

D. This PPDR is separated into 29 flight tasks to be recorded. Where applicable, each task is divided into segments that specify

observations that are to be made as objectively as possible. During a flight check, student performance normally is recorded during or near the end of each segment, provided that performance is within the limits specified as "proper" on all scales in that segment. Whenever an error exceeding "proper limits" of a scale occurs, the checkpilot should record it immediately, regardless of how much of the segment is completed. If, later in the segment, the student exceeds his previous error on the same scale, the checkpilot makes a second mark farther out on the scale. Generally speaking, erratic performance is reflected by multiple marking; for example, if the descent rate during an approach is uneven, both "slow" and "fast" may be marked.

E. There are three general levels of detail represented in the PPDR: (1) individual performance measures, (2) flight segments, and (3) flight tasks. Segments and measures are listed in the approximate sequence in which they occur during execution of the task. This is intended to simplify and standardize in-flight data recording.

Individual Performance Measures. The PPDR measuring scales show the detailed and descriptive criteria of student performance which underlie the evaluation made by the checkpilot. Examples of these scales are RPM, airspeed, altitude, and ground track. These scales are recorded objectively by the checkpilot from instruments or clearly definable outside references. However, it is not always possible to find such outside references for certain crucial aspects of student performance. Consequently, a few scales are judgmental in nature, e.g., pattern exit or control smoothness. The checkpilot must use his judgment in evaluating and recording these items.

Flight Segments. The subdivision of each PPDR flight task into its segments is indicated by single horizontal lines between segments. The segment breaks serve to remind the checkpilot of the time required for that particular group of measures. More importantly, they make it easier for the checkpilot to focus on a particular group of measures for the specific portion of flight performance being recorded. This reduces the difficulty in determining the flight performance sample to which each measure applies. Occasionally, a measure refers only to a specific part (beginning or end) of a segment; but these instances will be obvious to the checkpilot. Segments and measures are sequenced from the top of the page to the bottom.

Flight Tasks. There are several factors about the selected flight tasks that the PPDR seeks to control. One factor is the specification of performance measures and segments within tasks. The PPDR also requires that all students perform identical tasks, which ensures that the same behavioral patterns are sampled in all students. Because the sequence in which tasks are given during a flight check can affect the results, the sequence for the PPDR has been standardized. The sequence which has been settled upon should allow for maximum use of available time and resources. Due to the requirement for economy of time and effort in conducting the checkride, the

task performance sequence may be varied somewhat to expedite or to increase its efficiency or convenience. However, this standardized sequence should be followed as closely as possible. All tasks must be completed for each checkride, conditions permitting.

F. PPDR reliability is dependent upon the degree of standardization achieved in administering checkrides. It is essential that the checkpilot thoroughly understand each PPDR measure and its definition as described in this handbook. As a recorder, he is asked to provide accurate and descriptive information on the observed performance as it occurs. The recording function is extremely critical to the PPDR data collection effort. To achieve the goal of accuracy and completeness of recording, the subject's performance should be recorded as soon after it occurs as is practical, with due consideration for safety.

G. The checkpilot should maintain an impartial attitude toward the student, limiting conversation to explaining checkride requirements and conditions.

H. The pilot subject should not be given detailed feedback relative to checkride performance prior to debriefing.

I. Measures included in this PPDR are of two types:

Performance Scales with a desired range of values indicated by a triangular symbol at the scale midpoint, and errors (e.g., left/right) to either side of the triangle. For some measures a desired value is specified at the top of the triangle. Other measures include a '0' above the triangle, indicating that the checkpilot must determine the correct desired value depending upon the aircraft, airspace, or prevailing conditions.

Categorical Measures (yes or no) requiring the checkpilot to determine whether or not the observed performance is within acceptable limits. This determination involves more complex judgment for some measures (e.g., constant turn radius) than others (e.g., full throttle).

J. For the scale measures that include a specified deviation range (i.e., tolerance) around the midpoint, the tolerance band specified may or may not be identical to the standards given in the FAA flight test guide. These bands are not necessarily intended to denote FAA acceptable performance, but rather to generate accurate data to document observable performance differences.

K. This version of the PPDR is not intended for use in diagnosing student performance deficiencies. However, research has shown that use of the PPDR can lead to such diagnosis by providing instructors, checkpilots, and training managers with a valid and reliable performance data base describing typical and atypical student performance.

These data may then be used as an index of comparison (norm) for any given student's observed performance, and therefore provide effective performance feedback to that student.

IV. PPDR Data Recording

A. The cover page of the PPDR is divided into three parts. Part One contains descriptive information about the student, checkpilot, aircraft, etc. and should be completed in its entirety prior to the checkride. Part Two contains weather data. The direction and velocity of crosswind as well as existing turbulence should be recorded both before and after the checkride.

B. Each scale should be marked with at least one slash mark of approximately 1/4 inch in length. The mark should pass clearly and evenly through the scale such that there is no doubt about which scale or which portion of the scale the checkpilot intended to mark. Categorical measures should include a slash mark in the appropriate box.

C. For those segments encompassing an extended period of time (e.g., climbout and pattern exit after takeoff), multiple marks may be necessary. This gives a record of deviations as they are observed without forcing the checkpilot to rely upon his memory of an extended performance segment. Errors observed in both directions (e.g., low and high) should be appropriately recorded. Short term segments (e.g., flare) should include only one mark for each measure. Requirement for multiple marking should be apparent to the checkpilot.

D. If dangerous performance occurs, the checkpilot should write a letter "D" in the left margin and draw a line to the scale(s) reflecting the dangerous performance. If a flight task is aborted because of student-induced dangerous performance, an additional notation should be made in the margin and all remaining measures on that task marked in error.

E. If the checkpilot finds it necessary to assist the subject with a task, "CP Assist" should be noted in the margin for the affected portion of the task or segment.

F. Go-arounds and their reason should be noted in the margin (except when the go-around task is being assessed). When a go-around is initiated for any reason, the checkpilot shall note the go-around point on the PPDR, allow one additional approach, and begin marking at the point of go-around. If erratic student performance necessitates a second go-around, all remaining PPDR measures shall be marked in error, and PPDR recording shall terminate. If the go-arounds are, in the judgment of the checkpilot, weather or traffic-induced, a notation to that effect should be made in the margin, and remaining measures left unmarked.

PPDR MEASURE DEFINITIONS AND RECORDING GUIDELINES

The PPDR provides a record of what actually occurs during the checkride. The flight tasks included in this PPDR are intended to be performed under normal private pilot checkride conditions (i.e., no more than light to moderate wind and turbulence effects). As such, the PPDR tasks should not be deliberately assigned under extremely windy or turbulent conditions. However, if it is necessary to administer the PPDR in such conditions, an accurate recording of the characteristics of those conditions before and after the checkride will enable them to be considered in the overall analysis of performance. The checkpilot must not allow extraneous factors to influence his marking of the actual performance scales. However, he may note that extraneous factors have, in his judgment, influenced the performance of a task.

Measures are of two general types. One is a scale with a triangle provided at its midpoint. The triangle should be marked if performance is within nonerror limits (i.e., proper). Otherwise, deviations from these limits should be marked in the appropriate error direction (e.g., low or high). Recording should not attempt to reflect the exact number of units of deviation from the midpoint (e.g., both 7 knots and 9 knots should be marked midway between 5 and 10 knots).

The other measure is categorical, requiring the checkpilot to mark either "yes" or "no," depending on whether the observed performance relative to that measure was, in his judgment, acceptable. Measure definitions should be followed in this determination.

PERFORMANCE MEASURES.

Abeam Midpoint - On traffic pattern entry, mark "Yes" if entry is within an acceptable range, made abeam the midpoint of the runway; otherwise, mark "No."

Acceptable Rotation - If takeoff rotation is smooth and correctly timed, mark "Yes"; otherwise, mark "No."

Airspeed - If observed airspeed is within ±5 knots of the desired airspeed, proper should be marked; otherwise the direction and magnitude of error should be marked.

Altitude - If observed altitude is within ±50 feet of desired altitude, mark proper; otherwise, mark direction and magnitude of error.

Altitude Loss Acceptable - A measure of stall recovery skill, mark "Yes" if altitude loss during recovery is not greater than 50 feet; if altitude loss is judged excessive, mark "No."

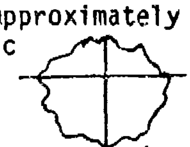
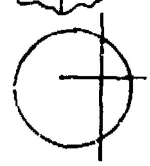
Angle (45°) - Traffic pattern entry track angle should be marked "Yes" if entry is made at approximately a 45° angle; otherwise, mark "No."

Approach Angle - If the approach to landing is judged to be within approximate range of the desired approach angle, mark proper; otherwise, mark whether the angle is too "shallow" or too "steep."

Bank - When turning, if the desired bank angle is maintained within ±5°, proper should be marked; otherwise, the direction and magnitude of error should be marked.

Carb Heat Off - Mark "Yes" or "No" as appropriate.

Cockpit Check - If all required cockpit procedures are satisfactorily performed, mark "Yes"; otherwise, mark "No."

Constant Radius Turn - A measure of wind drift correction in turns about a point, mark "Yes" if the turn radius is approximately equal throughout both turns: If the ground path is erratic  or if the turns are smooth but drift corrections are improper,  mark "No."

Contact - Mark proper if landing contact with the runway is correctly timed and smooth; otherwise, mark whether the aircraft was "dropped" or "bounced."

Control Coordination - A measure of general control skill, mark "Yes" if student maintains coordinated flight (± 1 ball) during turn. Otherwise, mark "No."

Degrees Turned - Mark proper if the observed number of degrees turned is within ±5° of the desired number of degrees turned; otherwise, mark the direction and magnitude of error.

Descent Rate - If the observed descent rate is judged to be within approximate range of the desired descent rate (e.g., 500 fpm), mark proper; otherwise, mark the direction of error ("slow" or "fast").

Distance Out - Mark proper if the traffic pattern is entered at the correct distance from the runway; otherwise, indicate whether entry is "too close" or "too far" from the runway.

Enter Downwind - Mark "Yes" if entry is, within acceptable limits, in a downwind direction; otherwise, mark "No."

Flaps (10°) - Mark "Yes" or "No" as appropriate.

Full Flaps - Mark "Yes" or "No" as appropriate.

Full Throttle - If throttle is full open, mark "Yes"; any throttle setting less than full should be marked "No."

Heading - Mark proper if observed heading is within $\pm 5°$ of desired heading: otherwise, mark direction and magnitude of error.

Level-off Altitude - Traffic pattern or assigned level-off altitude, if achieved within ± 50 feet, should be marked proper; otherwise, the direction and magnitude of error should be marked.

Maintain Airspace Scan - If student scans (with visible head movement) for other aircraft, mark "Yes"; otherwise, mark "No."

Mixture, Full Rich - Mark "Yes" or "No" as appropriate.

Pitch Decreased - A component of stall recovery skill, mark "Yes" if nose-up pitch is properly and immediately decreased after stall occurs; otherwise, mark "No."

Power, Idle - Mark "Yes" or "No" as appropriate.

Proper Entry Sequence - If all necessary procedures are performed in the correct sequence during entry, mark "yes"; if any procedure is omitted or out of sequence, mark "No".

Proper Flaps - If the flaps are set in the desired or assigned configuration, mark "Yes"; otherwise, mark "No."

Proper Flare Attitude - Mark proper if the aircraft is in the correct nose-up pitch attitude during the flare; otherwise, mark the direction of error ("nose low" or "nose high").

Proper Flare Rate - Mark proper if the flare rate is within proper limits given existing conditions; otherwise, mark whether the flare was too "slow" or too "fast."

Proper Ground Track - If the aircraft is maintained within an acceptable range of the desired ground track throughout a segment, mark "Yes"; otherwise, mark "No."

Proper Pattern Exit - When exiting the traffic pattern, mark "Yes" if exit is timely, at the proper location, altitude, and correct angle. If any one of these conditions is not satisfied, mark "No."

Proper Recovery Sequence - If all necessary procedures are performed in the correct sequence during recovery, mark "Yes"; if any procedure is omitted or out of sequence, mark "No."

Radial Identified - If student can correctly identify radial and orient accordingly, mark "Yes"; otherwise, mark "No."

Reduce Power - If power is reduced within a proper time range, mark proper; otherwise, mark whether power was reduced too "early" or too "late" in the traffic pattern.

RPM - If the desired RPM setting is maintained within ±50 RPM, proper should be marked; otherwise, the direction and magnitude of error should be marked.

Runway Centerline Track - This is a measure of directional control during takeoff and landing ground roll and should be marked proper as long as the runway centerline is within the wing tips. Deviations from centerline ("left" or "right") should be marked if the wingtip opposite the direction of deviation passes the runway centerline.

Smooth Control - If control movements are judged smooth and coordinated for all segments of the maneuver, mark "Yes." If any segment contains control movements that are erratic, of excessively large magnitude or frequency, or otherwise unacceptable, mark "No."

Stall Recognized - Timely and correct recognition of stall should be marked "Yes"; otherwise, mark "No."

Station Identified - If the student can correctly identify the VOR station within an acceptable time period, mark "Yes"; otherwise, mark "No."

Station Tuned Properly - If correct VOR station is correctly tuned within an acceptable time period, mark "Yes"; otherwise, mark "No."

Track from Extended Runway - A measure of track control after liftoff and during approach to landing, proper should be marked if the aircraft track is maintained within an acceptable track width from ground level to an altitude of 500 feet or until a turn is correctly initiated. If, in the checkpilot's judgment, proper track is not maintained during climbout or approach, "left" or "right" should be marked.

Touchdown Point - If the aircraft touches down within an acceptable range of the desired touchdown point, mark proper; otherwise, mark whether the observed touchdown is short or long relative to the desired or assigned touchdown point range.

Trim - A measure of ability to trim for hands-off flight, mark "Yes" if little or no control is required to maintain level flight; otherwise, mark "No."

Turn to Inbound Heading - If inbound heading is achieved within ±5° of that assigned, mark proper; otherwise, mark the direction and magnitude of error.

Turn Started - A measure of traffic pattern skill, mark proper if the turn is initiated within an acceptable distance of the desired or assigned turning point; otherwise, mark whether the turn was initiated too "early" or too "late."

VOR Track - Mark proper if the CDI needle is maintained within ± 1 dot of the circle for the duration of the track; otherwise, mark the direction and magnitude of error.

PILOT PERFORMANCE DESCRIPTION RECORD

1.

STUDENT'S NAME	SSN
TRACK	AIRCRAFT
CHECK PILOT	DATE

2. WEATHER

[L] [NONE] [R] X WIND 15° 30° 45° 60°	[L] [NONE] [R] X WIND 15° 30° 45° 60°
WIND VELOCITY (Knts) 5 10 15 20 GUSTS [NONE] [LIGHT] [MOD.]	WIND VELOCITY (Knts) 5 10 15 20 GUSTS [NONE] [LIGHT] [MOD.]

3. ROUTE IDENTIFICATION: ____________________

ENGINE RUNUP AND BEFORE TAKEOFF CHECK

BEFORE TAKEOFF PROCEDURES CORRECT YES NO

(If any step is omitted or performed incorrectly, please list it below.)

COMMENTS:

TAKEOFF AND DEPARTURE

GROUND RUN

FULL THROTTLE	YES	NO
RUNWAY CENTERLINE TRACK	LEFT	RIGHT

LIFTOFF

AIRSPEED	LOW	55 (-5 / +5)	HIGH
ACCEPTABLE ROTATION	YES		NO

CLIMBOUT

AIRSPEED	LOW	-5 / +5	HIGH
TRACK FROM EXTENDED RUNWAY	LEFT		RIGHT
PROPER PATTERN EXIT	YES		NO
PROPER TRIM (FOR CLIMB)	YES		NO

LEVEL OFF

ALTITUDE	LOW	-50 / +50	HIGH
TRIM (LEVEL FLIGHT)	YES		NO

SMOOTH CONTROL	YES	NO
CONTROL COORDINATION	YES	NO (SLIP / SKID)

TURBULENCE	YES	NO

COMMENTS:

SHORT FIELD TAKEOFF

GROUND RUN

FULL THROTTLE	YES	NO
RUNWAY CENTERLINE TRACK	LEFT	RIGHT

LIFTOFF

AIRSPEED	LOW	-5	+5	HIGH
ACCEPTABLE ROTATION	YES			NO

CLIMBOUT

INITIAL AIRSPEED (OVER OBSTACLE)	LOW	-5	+5	HIGH
AIRSPEED (AFTER OBSTACLE CLEARED)	LOW	-5	+5	HIGH
TRACK FROM EXTENDED RUNWAY	LEFT			RIGHT
PROPER TRIM (FOR CLIMB)	YES			NO

LEVEL OFF (IN PATTERN)

ALTITUDE	LOW	HIGH
TRIM (LEVEL FLIGHT)	YES	NO

SHORT FIELD TAKEOFF

SMOOTH CONTROL	YES	NO
CONTROL COORDINATION	YES	NO
		SLIP / SKID
TURBULENCE	YES	NO

COMMENTS:

SOFT FIELD TAKEOFF

GROUND RUN

PROPER USE OF FLAPS	YES	NO
INITIATED ROLLING START	YES	NO
FULL THROTTLE	YES	NO
RUNWAY CENTERLINE TRACK	LEFT	RIGHT

LIFTOFF

AIRSPEED AT LIFTOFF	LOW -5	+5 HIGH
ACCEPTABLE ROTATION	YES	NO

CLIMBOUT

MAINTAINS PROPER ATTITUDE UNTIL AIRSPEED BUILDS	YES	NO
AIRSPEED (AFTER STARTING CLIMBOUT)	LOW -5	+5 HIGH
TRACK FROM EXTENDED RUNWAY	LEFT	RIGHT
PROPER TRIM (FOR CLIMB)	YES	NO

SOFT FIELD TAKEOFF

LEVEL OFF (IN PATTERN)

ALTITUDE	LOW	HIGH
TRIM (LEVEL FLIGHT)	YES	NO
SMOOTH CONTROL	YES	NO
CONTROL COORDINATION	YES	NO (SLIP / SKID)
TURBULENCE	YES	NO

COMMENTS:

CROSSWIND TAKEOFF

GROUND RUN

FULL THROTTLE	YES	NO
FULL AILERON DEFLECTION	YES	NO
RUNWAY CENTERLINE TRACK	LEFT	RIGHT

LIFTOFF

AIRSPEED	LOW	-5	+5	HIGH
ACCEPTABLE ROTATION	YES	NO		
PROPER DRIFT CORRECTION	YES	NO		

CLIMBOUT

AIRSPEED	LOW	-5	+5	HIGH
TRACK FROM EXTENDED RUNWAY	LEFT			RIGHT
PROPER TRIM (FOR CLIMB)	YES	NO		

LEVEL OFF

ALTITUDE	LOW	HIGH
TRIM (LEVEL FLIGHT)	YES	NO

SMOOTH CONTROL	YES	NO
CONTROL COORDINATION	YES	NO (SLIP / SKID)

TURBULENCE	YES	NO

COMMENTS:

STRAIGHT AND LEVEL FLIGHT

AIRSPEED	-10	-5	105	+5	+10
HEADING	-10°	-5°		+5°	+10°
ALTITUDE	-100	-50		+50	+100
PROPER TRIM		YES		NO	
SMOOTH CONTROL		YES		NO	
TURBULENCE		YES		NO	

COMMENTS:

"S" TURNS ACROSS A ROAD

ENTERS DOWNWIND [YES] [NO]

1st TURN

ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10

CORRECT BANK ANGLES
FOR DRIFT CORRECTION [YES] [NO]

WINGS LEVEL AT ROAD [YES] [NO]

2nd TURN

ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10

CORRECT BANK ANGLES
FOR DRIFT CORRECTION [YES] [NO]

SMOOTH CONTROL [YES] [NO]

COORDINATED TURNS [YES] [NO]

TURBULENCE [YES] [NO]

COMMENTS:

TURNS ABOUT A POINT

ENTER DOWNWIND		YES		NO		
1st TURN						
ALTITUDE	-100		-50	+50		+100
AIRSPEED	-10		-5	+5		+10
2nd TURN						
ALTITUDE	-100		-50	+50		+100
AIRSPEED	-10		-5	+5		+10
CONSTANT RADIUS TURN		YES		NO		
PROPER EXIT HEADING	-10°		-5°	+5°		+10°
MAINTAIN AIRSPACE SCAN		YES		NO		
SMOOTH CONTROL		YES		NO		
TURBULENCE		YES		NO		

COMMENTS:

MINIMUM CONTROLLABLE AIRSPEED

ENTRY

PROPER ENTRY PROCEDURES	YES	NO

STRAIGHT AND LEVEL

AIRSPEED	-10	-5	+5	+10
ALTITUDE	-100	-50	+50	+100
HEADING	-10°	-5°	+5°	+10°

TURN

AIRSPEED	-10	-5	+5	+10
ALTITUDE	-100	-50	+50	+100

RECOVERY

PROPER RECOVERY PROCEDURES	YES	NO
PROPER USE OF POWER	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

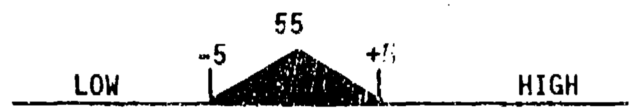
COMMENTS:

TAKEOFF AND DEPARTURE STALL

ENTRY

PROPER ENTRY PROCEDURES	YES	NO

AIRSPEED



RECOVERY

STALL RECOGNIZED	YES	NO
PITCH DECREASED	YES	NO
WINGS LEVEL	YES	NO
ALTITUDE LOSS ACCEPTABLE	YES	NO
AIRSPEED NOT EXCESSIVE	YES	NO

SMOOTH CONTROL	YES	NO

TURBULENCE	YES	NO

COMMENTS:

APPROACH TO LANDING STALL

ENTRY

PROPER ENTRY PROCEDURES	YES	NO

AIRSPEED

BANK

RECOVERY

STALL RECOGNIZED	YES	NO
FULL THROTTLE	YES	NO
PITCH DECREASED	YES	NO
WINGS LEVEL	YES	NO
CARB HEAT OFF	YES	NO
FLAP RETRACTION	YES	NO
ALTITUDE LOSS ACCEPTABLE	YES	NO
AIRSPEED NOT EXCESSIVE	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

ENGINE FAILURE PROCEDURES DURING FLIGHT

	YES	NO
ENGINE FAILURE PROCEDURES CORRECT		
AIRSPEED - 65 KIAS ($\pm$ 2 KNOTS)		
CARB HEAT ON		
FUEL SELECTOR VALVE ON BOTH		
MIXTURE RICH		
IGNITION SWITCH ON BOTH		
PRIMER - IN AND LOCKED		

COMMENTS:

STEEP TURNS (720°)

ENTRY

PROPER ROLLIN	YES	NO
PROPER USE OF POWER	YES	NO

			95		
AIRSPEED	-10	-5		+5	+10
ALTITUDE	-100	-50		+50	+100

BANK/TURN

			50°		
ANGLE BANK	-10	-5		+5	+10
			95		
AIRSPEED	-10	-5		+5	+10
ALTITUDE	-100	-50		+50	+100

STEEP TURNS (720°)

RECOVERY

PROPER LEAD		YES		NO		
ALTITUDE	-100	-50		+50	+100	
HEADING	-20°	-10°		+10°	+20°	
AIRSPEED	-10	-5	95	+5	+10	
PROPER POWER REDUCTION		YES		NO		
SMOOTH CONTROL		YES		NO		
TURBULENCE		YES		NO		

COMMENTS:

ACCELERATED STALL

ENTRY

AREA CLEARED		YES	NO	
MIXTURE RICH		YES	NO	
POWER (RPM)	-100	-50	+50	+100
ALTITUDE	-100	-50	+50	+100

BANK

INITIATE AT 55 KIAS (± 5 KNOTS)		YES	NO	
BANK ANGLE	-10°	-5°	+5°	+10°
ALTITUDE	-100	-50	+50	+100

RECOVERY

STALL RECOGNIZED	YES	NO
PITCH DECREASED PROPERLY	YES	NO
WINGS LEVELLED PROPERLY	YES	NO
FULL POWER	YES	NO
CARB HEAT COLD	YES	NO
PROPER CONTROL COORDINATION	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

MAGNETIC COMPASS TURN (W-S; 270°) (HOOD)

SETUP

PROPER SETUP		YES		NO	

ROLLIN

BANK	-10°	-5°		+5°	+10°
ALTITUDE	-100	-50		+50	+100

MAINTAIN

BANK	-10°	-5°		+5°	+10°
ALTITUDE	-100	-50		+50	+100

ROLLOUT

ALTITUDE	-100	-50		+50	+100
DEGREES TURNED	-10°	-5°	270	+5°	+10°
PROPER LEAD/LAG		YES		NO	

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

RATE CLIMB (HOOD)

INITIATE

POWER INCREASE (RPM)	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10
HEADING	-10°	-5°	+5°	+10°

MAINTAIN

VERTICAL SPEED (FPM)	-100	-50	+50	+100
HEADING	-10°	-5°	+5°	+10°

LEVELOFF

HEADING	-10°	-5°	+5°	+10°
ASSIGNED ALTITUDE	-100	-50	+50	+100

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

UNUSUAL ATTITUDE RECOVERIES (HOOD)

RECOGNITION

RECOGNITION OF ATTITUDE	YES	NO

RECOVERY

CORRECT AND TIMELY CONTROL MOVEMENTS	YES	NO
INITIAL ALTITUDE RECOVERED ($\pm$ 100ft.)	YES	NO
HEADING CONTROL (RECOVERY)	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

180° TURNS (HOOD)

PROPER ROLLIN		YES	NO	
BANK ANGLE	-10°	-5°	+5°	+10°
ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10	-5	+5	+10
ROLLOUT ON ASSIGNED HEADING	-10°	-5°	+5°	+10°
SMOOTH CONTROL		YES	NO	
TURBULENCE		YES	YES	

COMMENTS:

VOR TRACKING (CROSS-COUNTRY; INBOUND)

IDENTIFICATION

STATION TUNED PROPERLY		YES	NO	
STATION IDENTIFIED		YES	NO	
RADIAL IDENTIFIED		YES	NO	
ALTITUDE (DURING IDENTIFICATION)	-100	-50	+50	+100
HEADING (DURING IDENTIFICATION)	-10°	-5°	+5°	+10°

TRACK TO STATION

TURN TO INBOUND HEADING	-10	-5	+5	+10
ALTITUDE	-100	-50	+50	+100
AIRSPEED	-10°	-5°	+5°	+10°
VOR TRACK ($\pm$ 1 dot)		YES	NO	

TURBULENCE	YES	NO

COMMENTS:

FORCED LANDING

SELECTS FEASIBLE AREA FOR EMERGENCY LANDING	YES	NO
PROPERLY PLANS DIRECTION OF LANDING	YES	NO
PROPER AIRSPEED CONTROL (NOT EXCESSIVELY HIGH OR LOW)	YES	NO
MAINTAINS SCAN FOR HIGH OBSTACLES	YES	NO
WOULD OBTAIN DESIRED TOUCHDOWN POINT	YES	NO
VERBALIZED PROCEDURES FOR EMERGENCY LANDING	YES	NO

COMMENTS:

TRAFFIC PATTERN (UNCONTROLLED FIELD)

ENTRY

ANGLE (45°)		YES	NO	
ABEAM MIDPOINT		YES	NO	
ALTITUDE	-100	-50	+50	+100
RPM	-100	-50	+50	+100
DISTANCE OUT	TOO CLOSE			TOO FAR

DOWNWIND

ALTITUDE	-100	-50	+50	+100
COCKPIT CHECK		YES	NO	
REDUCE POWER	EARLY			LATE
AIRSPEED	-10	-5	+5	+10
FLAPS (10°)		YES	NO	
PROPER GROUND TRACK		YES	NO	
TURN STARTED (BASE)	EARLY			LATE

TRAFFIC PATTERN (UNCONTROLLED FIELD)

BASE

AIRSPEED	-10 -5 +5 +10
PROPER GROUND TRACK	YES NO
PROPER FLAPS	YES NO
TURN STARTED (FINAL)	EARLY LATE
TRIM	YES NO

FINAL

TRACK FROM EXTENDED RUNWAY	LEFT RIGHT
AIRSPEED	-10 -5 +5 +10
DESCENT RATE	SLOW FAST
APPROACH ANGLE	SHALLOW STEEP
PROPER FLAPS	YES NO
TRIM	YES NO

SMOOTH CONTROL	YES NO
TURBULENCE	YES NO

COMMENTS:

TYPE OF ENTRY (CHECK)

- [ ] DOWNWIND
- [ ] BASE
- [ ] FINAL

TRAFFIC PATTERN (CONTROLLED FIELD)

ENTRY

ANGLE (45°)		YES	NO	
ABEAM MIDPOINT		YES	NO	
ALTITUDE	-100	-50	+50	+100
RPM	-100	-50	+50	+100
DISTANCE OUT	TOO CLOSE			TOO FAR

DOWNWIND

ALTITUDE	-100	-50	+50	+100
COCKPIT CHECK		YES	NO	
REDUCE POWER	EARLY			LATE
AIRSPEED	-10	-5	+5	+10
FLAPS (10°)		YES	NO	
PROPER GROUND TRACK		YES	NO	
TURN STARTED (BASE)	EARLY			LATE

TRAFFIC PATTERN (CONTROLLED FIELD)

BASE

AIRSPEED	-10	-5	+5	+10
PROPER GROUND TRACK		YES	NO	
PROPER FLAPS		YES	NO	
TURN STARTED (FINAL)	EARLY			LATE
TRIM		YES	NO	

FINAL

TRACK FROM EXTENDED RUNWAY	LEFT			RIGHT
AIRSPEED	-10	-5	+5	+10
DESCENT	SLOW			FAST
APPROACH ANGLE	SHALLOW			STEEP
PROPER FLAPS		YES	NO	
TRIM		YES	NO	

COMMENTS:

GO-AROUND PROCEDURES

	YES	NO
GO-AROUND PROCEDURES CORRECT		
THROTTLE - FULL POWER		
PITCH ATTITUDE CHANGED		
CARB HEAT COLD		
FLAPS 20° MAXIMUM		
CLIMB 55 KIAS ($\pm$ 5 KIAS)		
FLAPS RETRACTED PROPERLY		

COMMENTS:

NORMAL LANDING (UNCONTROLLED FIELD)

TRANSITION (FLARE)

			20		
ALTITUDE	-10	-5		+5	+10
PROPER FLARE RATE		YES		NO	
PROPER FLARE ATTITUDE		YES		NO	

TOUCHDOWN

TOUCHDOWN POINT	SHORT		LONG
PROPER POWER	YES		NO
PROPER NOSE ATTITUDE	YES		NO
CONTACT	DROP		BOUNCE
RUNWAY CENTERLINE TRACK	LEFT		RIGHT

SMOOTH CONTROL	YES	NO

TURBULENCE	YES	NO

COMMENTS:

LANDING (CONTROLLED FIELD)

TRANSITION (FLARE)

	-10	-5	20	+5	+10
ALTITUDE					
PROPER FLARE RATE		YES		NO	
PROPER FLARE ATTITUDE		YES		NO	

TOUCHDOWN

TOUCHDOWN POINT	SHORT		LONG
PROPER POWER	YES	NO	
PROPER NOSE ATTITUDE	YES	NO	
CONTACT	DROP		BOUNCE
RUNWAY CENTERLINE TRACK	LEFT		RIGHT

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

SHORT FIELD LANDING (TRANSITION AND TOUCHDOWN)

TRANSITION (FLARE)

ALTITUDE	-10	-5 20 +5	+10
PROPER FLARE RATE		YES	NO
PROPER FLARE ATTITUDE		YES	NO

TOUCHDOWN

TOUCHDOWN POINT	SHORT		LONG
PROPER POWER		YES	NO
PROPER NOSE ATTITUDE		YES	NO
CONTACT	DROP		BOUNCE
RUNWAY CENTERLINE TRACK	LEFT		RIGHT
PROPER USE OF BRAKES		YES	NO

SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

SHORT FIELD LANDING (BASE AND FINAL)

BASE

AIRSPEED	-10	-5	+5	+10
PROPER GROUND TRACK (EXTENDED)		YES	NO	
PROPER FLAPS		YES	NO	
TURN STARTED (FINAL)	EARLY			LATE
TRIM		YES	NO	

FINAL

TRACK FROM EXTENDED RUNWAY	LEFT			RIGHT
AIRSPEED	-10	-5	+5	+10
DESCENT RATE	SLOW			FAST
APPROACH ANGLE	SHALLOW			STEEP
PROPER FLAPS		YES	NO	
TRIM		YES	NO	

CROSSWIND LANDING (TRANSITION AND TOUCHDOWN)

TRANSITION (FLARE)

ALTITUDE	-10 -5 20 +5 +10	
PROPER FLARE RATE	YES	NO
PROPER FLARE ATTITUDE	YES	NO
PROPER DRIFT CORRECTION	YES	NO

TOUCHDOWN

TOUCHDOWN POINT	SHORT	LONG
PROPER POWER	YES	NO
PROPER NOSE ATTITUDE	YES	NO
PROPER DRIFT CORRECTION	YES	NO
CONTACT	DROP	BOUNCE
RUNWAY CENTERLINE TRACK	LEFT	RIGHT
PROPER USE OF BRAKES	YES	NO
SMOOTH CONTROL	YES	NO
TURBULENCE	YES	NO

COMMENTS:

CROSSWIND LANDING (BASE AND FINAL)

BASE

AIRSPEED	-10	-5		+5	+10
PROPER GROUND TRACK		YES		NO	
PROPER FLAPS		YES		NO	
TURN STARTED (FINAL)	EARLY				LATE
TRIM		YES		NO	

FINAL

PROPER DRIFT CORRECTION		YES		NO	
TRACK FROM EXTENDED RUNWAY	LEFT				RIGHT
AIRSPEED	-10	-5		+5	+10
DESCENT RATE	SLOW				FAST
APPROACH ANGLE	SHALLOW				STEEP
PROPER FLAPS		YES		NO	
TRIM		YES		NO	

ALL AIRBORNE COMMUNICATION PROCEDURES

ALL FREQUENCIES TUNED CORRECTLY AND PROMPTLY	YES	NO
PROPER USE OF MIKE	YES	NO
SPEAKS CLEARLY	YES	NO
MAKES PROPER REQUESTS	YES	NO
UNDERSTANDS ALL MESSAGES	YES	NO
COMPLIES WITH ALL MESSAGES WHILE PERFORMING OTHER TASKS	YES	NO

COMMENTS:

APPENDIX B

PRE AND POSTCHECK QUESTIONNAIRES

This appendix contains copies of (1) the precheck questionnaire, which asked students to predict how they would perform on the 8-month retention check; and (2) the postcheck questionnaire, which asked them to evaluate their performance after they had completed the retention check.

PHASE CHECK: III IV
(circle one)

STUDENT PRECHECK QUESTIONNAIRE

NAME: ______________________ SOC. SEC. NO: ______________________

This questionnaire is part of the overall experiment of which your training is a part. Objective data concerning your flight skills are being gathered through the use of the phase checks with which you are already familiar. The purpose of this questionnaire is to obtain your own subjective assessment of your skills. This assessment will be compared with the objective measures obtained during the phase checks and with subjective ratings you will make after your checkride on a Postcheck Questionnaire.

The data obtained from these questionnaires will aid in the determination of the abilities of private pilots to assess their own skills. Such a determination is of great importance since general aviation pilots, once they have received their certificates, must be able (1) to judge if they can perform certain flight tasks safely, (2) to assess the adequacy with which they accomplish tasks they do perform, and (3) to determine when they need refresher or additional training to improve their skills. Increased understanding of the ability of general aviation pilots to make these judgments will aid in determining how to prevent accidents from happening in which pilots attempt maneuvers that are beyond their skill levels.

None of the instructors, including the one who is administering your checkride, will see your answers to this or the Postcheck Questionnaire. Please be frank and provide honest estimates of your ability to perform these tasks.

Please rate your ability to perform the following tasks, using the 7-point scale provided next to each task. Descriptive statements for scale points 1, 3, 5, and 7 are as follows:

1. I will probably be able to perform the task with NO ERRORS.

3. I will probably make a FEW ERRORS, but I will perform the task well enough to pass it easily on my checkride.

5. I will probably make SEVERAL ERRORS and barely pass the task on my checkride.

7. I will probably make MANY ERRORS and be unable to perform the task satisfactorily on my checkride.

Circle the number that best indicates how well you will perform each task on the checkride you are about to take.

	TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
1.	Planning a cross-country trip	1	2	3	4	5	6	7
2.	Conducting an engine run up and before takeoff check	1	2	3	4	5	6	7
3.	Taking off and departing from ACY	1	2	3	4	5	6	7
4.	Tracking a VOR signal	1	2	3	4	5	6	7
5.	Flying straight and level	1	2	3	4	5	6	7
6.	Flying at minimum controllable airspeed	1	2	3	4	5	6	7
7.	Performing takeoff and departure stalls	1	2	3	4	5	6	7
8.	Performing approach to landing stalls	1	2	3	4	5	6	7
9.	Performing steep turns (720°)	1	2	3	4	5	6	7
10.	Performing accelerated stalls	1	2	3	4	5	6	7
11.	Performing engine failure during flight procedures	1	2	3	4	5	6	7
12.	Performing forced landing procedures	1	2	3	4	5	6	7
13.	Performing go-around procedures	1	2	3	4	5	6	7
14.	Flying a traffic pattern at an uncontrolled field	1	2	3	4	5	6	7
15.	Making a normal landing at an uncontrolled field	1	2	3	4	5	6	7
16.	Making short field takeoffs (uncontrolled field)	1	2	3	4	5	6	7
17.	Making short field landings (uncontrolled field)	1	2	3	4	5	6	7

	TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
18.	Making soft field takeoffs (uncontrolled field)	1	2	3	4	5	6	7
19.	Making crosswind landings (uncontrolled field)	1	2	3	4	5	6	7
20.	Making crosswind takeoffs (uncontrolled field)	1	2	3	4	5	6	7
21.	Making S turns across a road	1	2	3	4	5	6	7
22.	Making turns about a point	1	2	3	4	5	6	7
23.	Performing a rate climb under the hood	1	2	3	4	5	6	7
24.	Performing a magnetic compass turn under the hood	1	2	3	4	5	6	7
25.	Performing unusual attitude recoveries under the hood	1	2	3	4	5	6	7
26.	Performing 180° turns under the hood	1	2	3	4	5	6	7
27.	Flying a traffic pattern at a controlled field (ACY)	1	2	3	4	5	6	7
28.	Making a normal landing at ACY	1	2	3	4	5	6	7
29.	Performing all radio communication tasks	1	2	3	4	5	6	7

PHASE CHECK: III IV
(circle one)

STUDENT POSTCHECK QUESTIONNAIRE

NAME: ______________________ SOC. SEC. NO: ______________________

Now that you have taken your checkride, please rate your performance on that flight on the following tasks using the 7-point scale beside each task. Descriptive statements for scale points 1, 3, 5, and 7 are as follows:

1. I performed the task with NO ERRORS.

3. I made a FEW ERRORS, but probably performed the task well enough to pass it easily.

5. I made SEVERAL ERRORS and probably barely passed the task.

7. I made MANY ERRORS and probably did not perform the task satisfactorily.

Circle the number that best indicates how well you performed each of the following tasks.

TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
1. Planning a cross-country trip	1	2	3	4	5	6	7
2. Conducting an engine run up and before takeoff check	1	2	3	4	5	6	7
3. Taking off and departing from ACY	1	2	3	4	5	6	7
4. Tracking a VOR signal	1	2	3	4	5	6	7
5. Flying straight and level	1	2	3	4	5	6	7
6. Flying at minimum controllable airspeed	1	2	3	4	5	6	7
7. Performing takeoff and departure stalls	1	2	3	4	5	6	7
8. Performing approach to landing stalls	1	2	3	4	5	6	7

	TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
9.	Performing steep turns (720°)	1	2	3	4	5	6	7
10.	Performing accelerated stalls	1	2	3	4	5	6	7
11.	Performing engine failure during flight procedures	1	2	3	4	5	6	7
12.	Performing forced landing procedures	1	2	3	4	5	6	7
13.	Performing go-around procedures	1	2	3	4	5	6	7
14.	Flying a traffic pattern at an uncontrolled field	1	2	3	4	5	6	7
15.	Making a normal landing at an uncontrolled field	1	2	3	4	5	6	7
16.	Making short field takeoffs (uncontrolled field)	1	2	3	4	5	6	7
17.	Making short field landings (uncontrolled field)	1	2	3	4	5	6	7
18.	Making soft field takeoffs (uncontrolled field)	1	2	3	4	5	6	7
19.	Making crosswind landings (uncontrolled field)	1	2	3	4	5	6	7
20.	Making crosswind takeoffs (uncontrolled field)	1	2	3	4	5	6	7
21.	Making S turns across a road	1	2	3	4	5	6	7
22.	Making turns about a point	1	2	3	4	5	6	7
23.	Performing a rate climb under the hood	1	2	3	4	5	6	7
24.	Performing a magnetic compass turn under the hood	1	2	3	4	5	6	7
25.	Performing unusual attitude recoveries under the hood	1	2	3	4	5	6	7
26.	Performing 180° turns under hood	1	2	3	4	5	6	7

	TASKS	NO ERRORS		FEW ERRORS		SEVERAL ERRORS		MANY ERRORS
27.	Flying a traffic pattern at a controlled field (ACY)	1	2	3	4	5	6	7
28.	Making a normal landing at ACY	1	2	3	4	5	6	7
29.	Performing all radio communication tasks	1	2	3	4	5	6	7

APPENDIX C

PRIVATE PILOT SURVEY

This appendix contains a copy of the Private Pilot Survey that was used to obtain data related to subjects' flight experience since certification. These data were acquired prior to each retention check and were correlated with flight performance data.

PRIVATE PILOT SURVEY

NAME: ______________________________ SOC. SEC. NO. ______________________________

The purpose of this survey is to obtain information concerning your flight experience since certification. Your answers to these questions will be used to aid in identifying and analyzing factors affecting the retention of private pilot flight skills.

Your answers to questions in this survey will remain <u>anonymous</u>. That is, answers given by specific individuals will not be discussed with Embry-Riddle flight instructors or FAA personnel. Your name is needed, however, to enable the information obtained from this survey to be analyzed with respect to other data collected during this study--e.g., flight check data.

1. How many total hours have you flown (including during your private pilot training)? [ ] HOURS

When did you pass the FAA flight test?

______ Day ______ Month ______ Year

a. How many total hours have you flown in the interval between when you passed the FAA flight test and now? [ ] HOURS

b. How many flights (log entries) did you make during this time interval? [ ] HOURS

c. Identify the type of aircraft you have flown in the interval between when you passed the FAA flight test and now; list the number of hours you have in each type. (Write on back if you need more space.)

________________ [ ] HOURS

________________ [ ] HOURS

________________ [ ] HOURS

________________ [ ] HOURS

4. How many cross-country hours have you flown in the interval between when you passed the FAA flight test and now? [ ] HOURS

5. How many dual hours have you flown in the interval between when you passed the FAA flight test and now? [ ] HOURS

6. How many hours have you flown while receiving "under-the-hood" instructions in the interval between when you passed the FAA flight test and now? [ ] HOURS

7. How many hours have you "flown" in simulators or other training devices in the interval between when you passed the FAA flight test and now? [ ] HOURS

8. Approximately how many hours have you flown as a passenger (nonpilot) in a general aviation aircraft (excluding commuters and air taxis) in the interval between when you passed the FAA flight test and now? [ ] HOURS

9. Enter the approximate number of total hours you have flown in the interval between when you passed the FAA flight test and how for each of the following reasons.

   a. Pleasure (not cross-country) ______ HOURS

   b. Transportation (cross-country for business or pleasure) ______ HOURS

   c. Instruction

      - Refresher training or other training that is not directed toward a new certificate or rating ______ HOURS

      - Multiengine rating ______ HOURS

      - Instrument (IFR rating) ______ HOURS

      - Other (describe) ______ HOURS

10. When was the last time you flew? ______ Day ______ Month ______ Year

11. When was the next to the last time you flew? ______ Day ______ Month ______ Year

12. How often do you regularly fly? (Circle the letter of the best answer.)

   a. None
   b. An average of 1-4 hours a month
   c. An average of 5-10 hours a month
   d. An average of 10-20 hours a month
   e. An average of more than 20 hours a month

13. If you do not fly as often as you would like to fly, please circle all of the reasons you do not fly.

   a. High costs
   b. Lack of time
   c. Would rather do other activities
   d. Spouse does not want me to fly more often
   e. Weather
   f. Other (describe) ______________________

14. In general, how much has your flight experience aided you in the performance of your job at the Technical Center?

   a. Not at all
   b. Very little
   c. A little
   d. A moderate amount
   e. A substantial amount
   f. A extreme amount

15. In the interval since you passed your FAA flight test, on what percentage of the flights that you have flown have you performed the following tasks? Circle the number which best indicates the percentage of flights on which you performed each task. If you have not flown at all, leave this question blank.

TASKS	NEVER	LESS THAN 10 PERCENT OF MY FLIGHTS	10-50 PERCENT OF MY FLIGHTS	50-90 PERCENT OF MY FLIGHTS	90-100 PERCENT OF MY FLIGHTS
Planning a cross-country trip	1	2	3	4	5
Conducting an engine run up and before takeoff check	1	2	3	4	5
Taking off and departing from ACY	1	2	3	4	5
Tracking a VOR signal	1	2	3	4	5
Flying straight and level	1	2	3	4	5
Flying at minimum controllable airspeed	1	2	3	4	5
Performing takeoff and departure stalls	1	2	3	4	5
Performing approach to landing stalls	1	2	3	4	5
Performing steep turns (720°)	1	2	3	4	5
Performing accelerated stalls	1	2	3	4	5
Performing engine failure procedures during flight	1	2	3	4	5
Performing forced landing procedures	1	2	3	4	5

TASKS	NEVER	LESS THAN 10 PERCENT OF MY FLIGHTS	10-50 PERCENT OF MY FLIGHTS	50-90 PERCENT OF MY FLIGHTS	90-100 PERCENT OF MY FLIGHTS
Performing go-around procedures	1	2	3	4	5
Flying a traffic pattern at an uncontrolled field	1	2	3	4	5
Making a normal landing at an uncontrolled field	1	2	3	4	5
Making short field takeoffs (uncontrolled field)	1	2	3	4	5
Making soft field takeoffs (uncontrolled field)	1	2	3	4	5
Making crosswind landings (uncontrolled field)	1	2	3	4	5
Making crosswind takeoffs (uncontrolled field)	1	2	3	4	5
Making S turns across a road	1	2	3	4	5
Making turns about a point	1	2	3	4	5
Performing a rate climb under the hood	1	2	3	4	5
Performing a magnetic compass turn under the hood	1	2	3	4	5
Performing 180° turns under the hood	1	2	3	4	5
Flying a traffic pattern at a controlled field	1	2	3	4	5
Making a normal landing at a controlled field	1	2	3	4	5
Performing all radio communications tasks	1	2	3	4	5